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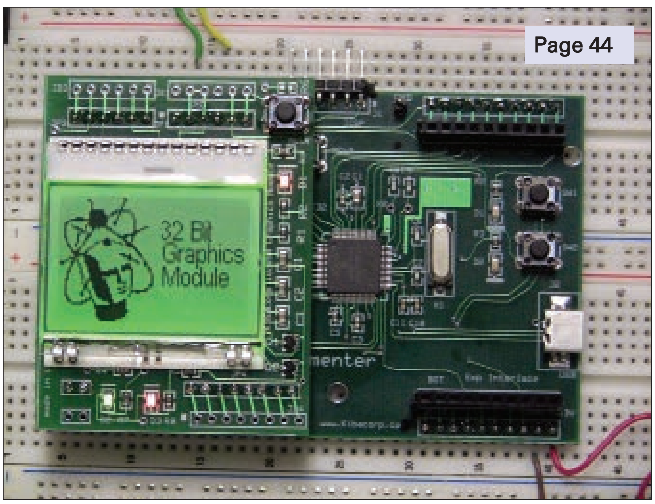
Projects & Features



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FUNdamentals For Beginners

Just getting started in electronics? Try these simple demos to illustrate electronics principles and how components function in actual circuits!

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DEVELOPING PERSPECTIVES

SPECTRUM-ACE First Impressions

One of the perks of my position at *Nuts & Volts* is the opportunity to work with products before they're available on the market. Of course, there's no such thing as a free sample, since each new gizmo or circuit requires an investment of time and energy to evaluate. As a result, I have a junk box full of small kits, chips, and boards. As you might expect, most of the components I get to evaluate are microprocessors. It seems like there's always a smaller, faster, and sometimes cheaper microprocessor on the horizon. In contrast, there isn't much to write about in new resistors, capacitors, or other discrete components.

One of the more notable products that I've been able to preview is a new microcontroller system from I2I Controls (**www.i2icontrols.com**). The system — called Spectrum-ACE — is actually a family of single-board computers and a set of development tools that works across the various boards. As with the Parallax Stamp or the Arduino family, you can move up in capability without having to learn a new set of tools. The boards have price points of $59, $79, and $99. There's also a starter kit, evaluation package with proto board area, and a more fully-featured evaluation board — similar to those available from the major microcontroller manufacturers.

Where this family of microcontrollers differs from the other platforms on the market is in the processing power and real time operating system. It's based on the 30 MIPS Dallas Semiconductor DS89C450 Flash microcontroller. The power of the chip and operating system enable you to add mass storage, drivers, communications, and other features normally associated with a microcomputer rather than a microcontroller with A/D conversion and digital I/O.

If you're a regular reader of my column, you know

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that I'm a fan of the Parallax Stamp and Propeller chips, the Atmel AVR, as well as the Arduino line of microcontrollers. However, each line of processors and associated development suites has its limitations. For example, several years ago I developed a crawler robot that simply required more processing power than these chips — or those from TI or Microchip — could provide. I was forced to work with a much more expensive single-board computer running a real time version of Linux in order to process inputs from multiple sensors while keeping the robot moving and on course.

If I were building the robot today, I'd try the $99 Spectrum-ACE board before spending a grand on a license for RT-Linux and a 5" x 5" single-board computer. Whether this family of microcontrollers is best for your project depends on what you need to do and your experience with microcontrollers. For example, if you need something that fits in a thumb drive, you'll have to look to one of the other microcontroller companies. These are solid boards designed for commercial applications. The large 60-pin Spectrum ACE 2s board measures 1.5" x 3.8".

If you're new to microcontrollers, don't need a real time operating system, and need a library of code to handle the popular sensors, motors, and peripherals out there, you might find the Spectrum-ACE a bit daunting. There's a lot of sample code for the established microcontrollers. However, if you're limited by the processing power, memory, or communications capabilities of your current microcontroller line, the Spectrum-ACE is worth considering. If you're more into the software side of development, it's also an inexpensive educational platform to learn the basics of real time operating systems. **NV**

READER FEEDBACK

FUEL FOR THOUGHT

I built the true reading fuel gauge from the April '11 issue and it works good. I had the requirement that I had to be able to build it entirely out of the stock in my shop. So, the LED unit is different and I didn't have a 400 kHz resonator. I used a 4 MHz crystal oscillator with a divide by 10 counter to scale it down instead of the resonator.

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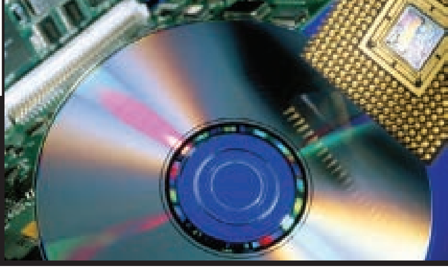


TECH KNOWLEDGEY 2011

EVENTS, ADVANCES, AND NEWS

■ BY JEFF ECKERT

ADVANCED TECHNOLOGY

MULTIFUNCTION HEART CATHETER "MAPS AND ZAPS"

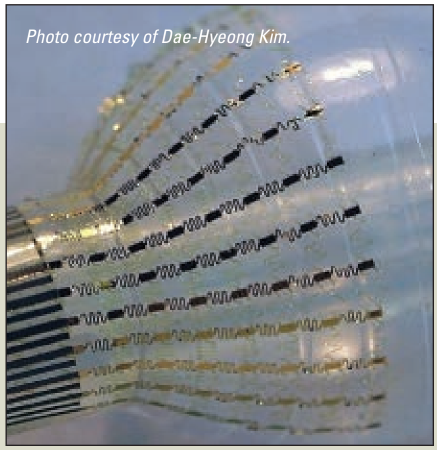
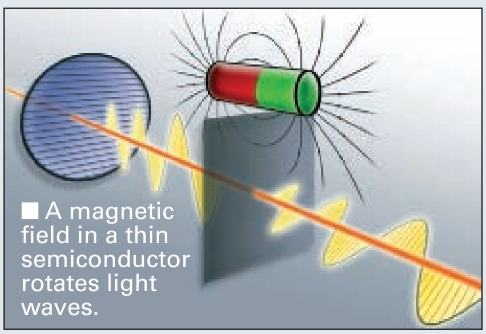


Photo courtesy of Dae-Hyeong Kim.

■ Inflated multifunctional balloon fitted with temperature, tactile, and EKG sensors.

Cardiac angioplasty has been around since 1977, when it was first performed at the University Hospital in Zurich. It's a fairly cheap and common procedure these days, but if you want to do more than just squash some plaque against the vessel walls with a balloon, you may need to insert two separate, rigid catheters: one that meticulously creates a point-by-point map of the heart and locates irregularities; and another electrode-tipped one to ablate aberrant spots. However, a team of materials scientists, mechanical and electrical engineers, and physicians at the University of Illinois (**illinois.edu**) have improved upon the standard endocardial balloon catheter by adding temperature, tactile, and EKG sensors that can perform the mapping function in a single step. You just inflate it in the cavity in question and push the electronics against the inside of it. The device then measures cardiac electrical activity, temperature, and blood flow. Because the balloon is also fitted with electrodes for ablation, it can eliminate the need for a second device. As one of the team members capsulized, it "maps and zaps." Last year, the team announced development of a sensor-laden sheet that could be laminated to the heart's surface; this is an adaptation of that technology. They simply mounted a meshwork of tiny sensor nodes onto a conventional balloon, and voilà! The device isn't available to surgeons just yet, but team leader John A. Rogers has co-founded mc10, Inc. (**mc10inc.com**), to commercialize the concept for both medical and non-medical applications. The company has tested the devices in live animal experiments with collaborators at both the University of Arizona and Massachusetts General Hospital, and so far, so good. The next step is to increase the sensor density level so that thousands of multiplexed devices can exist on a balloon's surface. Eventually, the device should enable more sophisticated and efficient diagnosis and treatment of arrhythmias with minimal invasiveness. ▲

NEW SPIN ON LIGHTWAVES



■ A magnetic field in a thin semiconductor rotates light waves.

Way back in 1845, Michael Faraday discovered a magneto-optical phenomenon in which light and a strong magnetic field can interact to cause a rotation in the light's plane of polarization; i.e., its vibrations will shift to a different direction. Apparently, because it is very weak, the "Faraday effect" has been useful only in a few applications for measurement instruments. In a recent issue of the journal *Physical Review Letters*, some physicists from the Vienna University of Technology (**www.tuwien.ac.at**) described experiments in which they — along with researchers at the University of Würzburg (**www.uni-wuerzburg.de**) — developed a method to control and manipulate the polarization of light.

Using light at a particular wavelength and "extremely clean semiconductors," they achieved a Faraday effect that is in orders of magnitude stronger than ever measured before. This allowed them to rotate light waves in arbitrary directions, with the direction tuned using an external magnetic field. More specifically, a layer of mercury telluride semiconductor is irradiated with infrared light. The light causes oscillations in the electrons, and the magnetic field deflects their vibrations. This, in turn, affects the beam of light and changes its polarization.

In the short term, the newly discovered effect will be useful primarily as a research tool. Note, however, that it is highly analogous to the operation of an electronic transistor. In a transistor, current is controlled by an external signal. In this experiment, a beam of light is controlled by an external magnetic field. This could form the basis of an optical transistor which, in turn, could lead to an entirely new computer technology. As observed by Prof. Andrei Pimenov, "The light has a frequency in the terahertz domain, and those are the frequencies future generations of computers may operate with ... We could call our system a light-transistor." ▲

COMPUTERS AND NETWORKING

FUJITSU SERVES UP A CLEAN SLATE

In the post-PC era, it gets a little complicated trying to keep track of the plethora of computing device mutations, so let us first establish that a "slate tablet PC" is a portable device that is very thin, looks pretty much like just a screen, and does not use standard hardware input devices such as a mouse or keyboard; hence "clean as slate." They are thin and meant to be held in one hand while you use the other to operate the device via the touchscreen which (among other things) includes a digital keyboard. Falling into this category (although it does include a pen input) is Fujitsu's new Stylistic® Q550, described as "a professional-oriented product designed to help mobile field workers maximize their productivity."

Introduced in March at CeBIT, it was designed with enhanced security features to address the IT security requirements of both corporate and government entities. The Q550 incorporates a suite of security features including a fingerprint sensor, an integrated SmartCard reader slot, full disk encryption, and an optional embedded Trusted Platform Module (TPM) to prevent unauthorized access to the user's personal and business data. One of its claims to fame is a 10.1 inch LED backlit IPS (in-plane switching) display that provides better color reproduction and a wider viewing angle than the more common TN (twisted nematic) displays. The device also includes WLAN, Bluetooth, and optional broadband 3G. Other specs include noise-cancelling dual microphones, front- and rear-facing cameras, 2 GB of on-board memory, a quick-change two- or four-cell battery, and Windows 7 Pro 32-bit loaded. As of this writing, the Q550 has not been released, but by the time you read this it should be available through retailers or the company's online store (**www.shopfujitsu.com**) starting at about $800. ▲

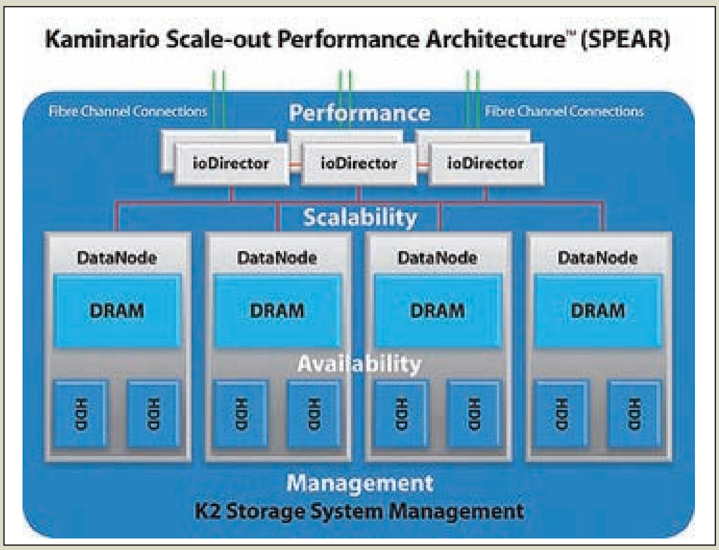
Photo courtesy of Fujitsu.

■ Fujitsu's Stylistic Q550 slate tablet.

$100/GB STORAGE?

The last time I visited an online hardware vendor, I noticed that 500 GB hard drives were selling for about $59. It was therefore somewhat mind boggling to see a 500 GB storage system offered at $50,000. But such is the new version of the Kaminario (**www.kaminario.com**) K2 DRAM storage appliance. Not only that, this is the low-end configuration, with larger units costing much, much more. So, here's the deal. The fifty-grand box can generate 150,000 I/O operations per second (IOPS) and 1.6 GB/s throughput. That's pretty impressive compared to the, oh, 40 MB/s you're probably getting with your USB 2.0 drive.

Kaminario achieves this via its SPEAR grid architecture (creatively derived from "Scale-out Performance Architecture") which is made up of I/O Directors, DRAM blades, and DataNodes. Each of the latter contains two SAS hard drives for data backup and two Fibre Channel ports to connect to your existing storage network. Whereas most of us don't really need performance at that level, the devices seem to meet price performance demands in such areas as oil exploration, banking, government research, and so forth. If you need more than 500 GB of storage, check out the 12 TB unit that can give you 1.5 million IOPS and 16 GB/s throughput. It's only $1.5 million. ▲



■ Kaminario's SPEAR grid architecture.

CIRCUITS AND DEVICES

INDUSTRY'S FIRST "MOBILE MIMO" WI-FI DEVICE

■ Marvell's Avastar 88W8797 (two antennas) compared to a standard configuration.

It's no secret that first-generation tablets have provided less than stellar wireless performance which is widely attributed to the design and placement of a single antenna in the Wi-Fi circuitry. However, the Marvell Technology Group (**www.marvell.com**) is offering a solution in the form of its Avastar™ 88W8797 — an 802.11n 2x2 dual-band Wi-Fi SoC designed to support high data rates required in a range of next-generation mobile devices. According to Marvell, "Given a tablet's unique industrial form factor, device designers and manufacturers have little flexibility in the physical location of the antenna on the device. Marvell's new mobile technology alleviates this challenge by adding a second transceiver in a true MIMO [multiple input, multiple output] configuration."

The device comes equipped with Tx beamforming technology, enabling a more expansive network range, and it supports the Bluetooth low energy ecosystem, allowing it to communicate with a wider range of mobile devices, including health monitoring systems and remote controls for home automation applications. The 88W8797 offers Wi-Fi data rates up to 300 Mbps and is said to be well suited for home media servers, notebook computers, set-top boxes, and digital TVs. ▲

MAKING GREEN FUN

■The Fiik Big Daddy electric skateboard.

We recently stumbled across the website of the Fiik skateboard company which seems to be made up of a bunch of crazy Aussie (sorry if that's redundant) sidewalk surfers who build crazy vehicles. The bad news is that they don't sell overseas from the website. The good news is that we later tracked down the North American reps at **www.fiikskate.com**, so if you're looking to save energy, have some fun, and probably suffer multiple fractures, check it out.

Perhaps the most intriguing is the Big Daddy model — "the biggest, baddest board in the Fiik range." It's also the fastest via its 10.5 in knobby tires (suitable for offroad operation) and an 800W, 36V motor. The deck is 45 inches long, concave, and made of Canadian maple, and it can support loads (that's you) up to 135 kg (300 lb). The board is powered by your choice of a lithium or sealed lead-acid battery, and the company claims a 30 km (18.6 mi) range and a top speed of 37 km/h (23 mph). You use a wireless controller as the throttle; squeezing the trigger increases your speed, whereas a forward push engages an electronic brake. Details are available at **www.fiikskate.com**, including the price tag of $1699. If you can't quite handle that, take a look at item 79798 at **www.hammacher.com**. The specs aren't quite as good, but it sure looks like a rebranded Big Daddy, and it's "only" $749.95. Either way you go, make sure your major medical is paid up before ordering. ▲

INDUSTRY AND THE PROFESSION

WD BUYS HITACHI

In a move that probably didn't create a lot of joy at Seagate, Western Digital (WD, **www.wdc.com**) recently announced that it will be acquiring Hitachi Global Storage Technologies (GST, **www.hitachigst.com**) in a stock and cash transaction valued at about $4.3 billion. In the fourth quarter of 2010, according to market research firm IDC, WD had a slim market lead (31.2%) over Seagate (29.2%). When you add Hitachi's 18.1% share, however, WD pulls significantly into the lead. The resulting company will retain the Western Digital name and remain headquartered in Irvine, CA. ▲

INDUSTRY AND THE PROFESSION *continued*

AND THE WINNER IS ...

Les Valiant, winner of the 2010 Turing Award.

The Association for Computing Machinery (ACM, **www.acm.org**) has handed out the A. M. Turing Award annually since 1966, for individuals who have made contributions of "lasting and major technical importance to the computer field." It is, of course, named for Alan Turing, creator of the Turing Machine — a theoretical device that was a precursor to the digital computer. Winner Les Valiant was cited for his "transformative contributions to the theory of computation, including the theory of probably approximately correct (PAC) learning, the complexity of enumeration and of algebraic computation, and the theory of parallel and distributed computing."

Perhaps best of all is that the award comes with a cool $250,000 provided by Intel and Google. Congrats, Les. **NV**

■ BY RON HACKETT

INTRODUCING THE PICAXE AXE401 SHIELD BASE

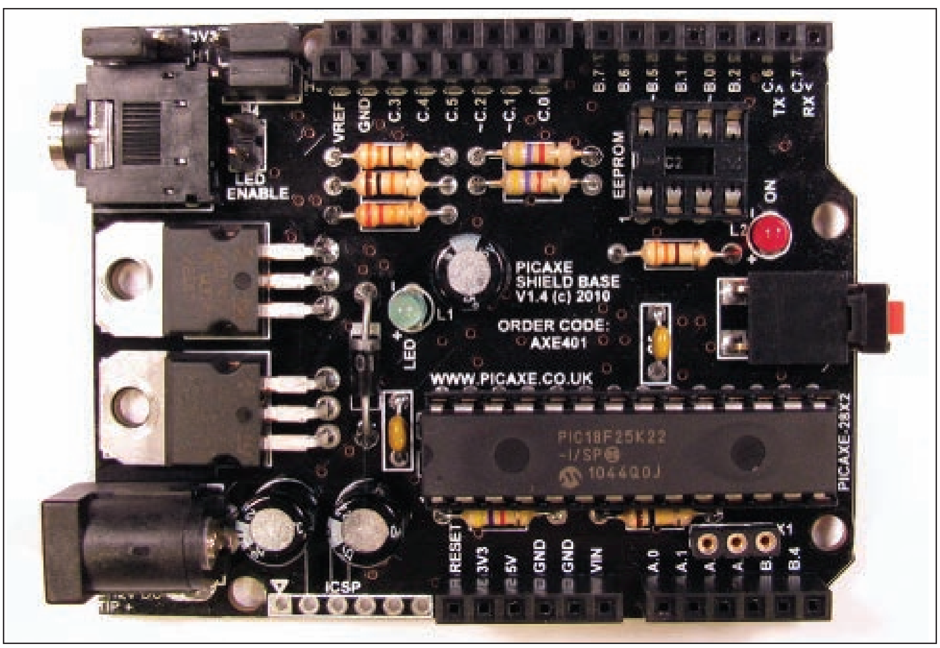
If you're a regular reader of the PICAXE Primer, the title of this month's column is bound to be a little confusing. In the previous Primer installment, I said that I still wanted to experiment with the possibility of using a touch sensor underneath a doormat or other small carpet to determine when someone is standing on or has walked across the carpet. At some point in the near future, I will definitely do that, but Revolution Education has released the AXE401 Shield Base (March '11) — an exciting new product that's going to open up a whole new world of possibilities for PICAXE projects. So, I hope you'll forgive me for putting the remainder of our capacitive-touch experiments on hold temporarily while I share what I have learned so far about the AXE401. I have only had my 401 for about a week, so the following discussion is somewhat preliminary, but I didn't want to allow another two months to go by without "spreading the word" about this new board.

OVERVIEW OF THE AXE401 SHIELD BASE

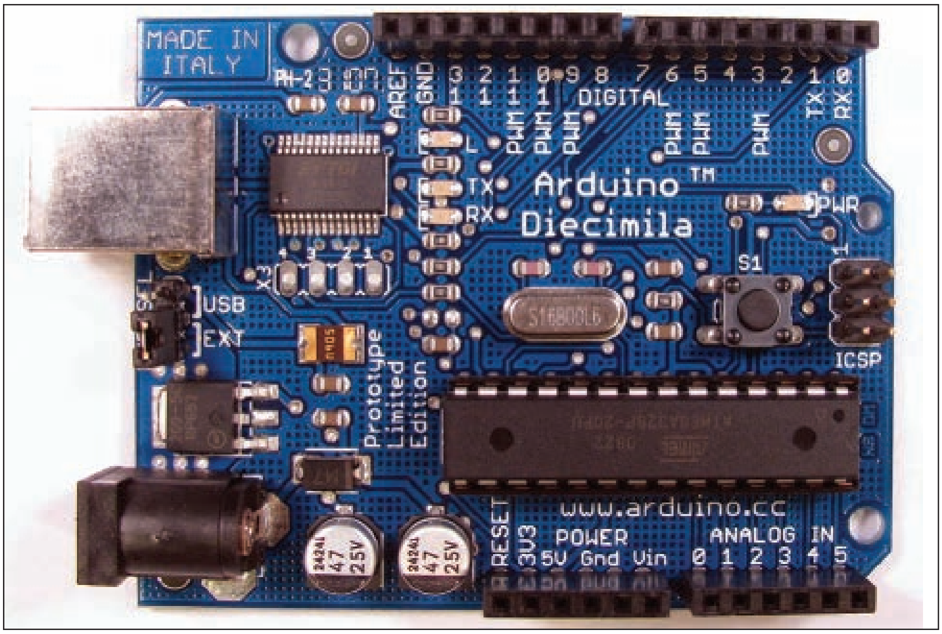
Essentially, the AXE401 Shield Base is a project board that's based on the newly upgraded PICAXE-28X2 processor that I mentioned in a previous column. What makes it so exciting is that the 401 is specifically designed to be compatible — both in form and function — with the popular line of Arduino microprocessor boards. (If you read *Nuts & Volts* regularly, I'm sure you're aware of the world of Arduino programming; if not, a quick online search will bring you up to speed in that area.)

Take a look at the photos presented in **Figures 1** and **2**, and you'll see what I mean by "compatible in form." **Figure 1** shows the AXE401 board, and **Figure 2** is the Arduino Diecimila board. The size and shape of the two boards are identical. More importantly, so is the layout of the I/O headers on each edge of the boards (with one important exception that we'll get to shortly). All the standard Arduino boards have the same I/O connections. (There are larger "Arduino Mega" boards that have many more I/O lines, but we'll focus on the standard boards.)

The standardization of the physical arrangement of the Arduino I/O connections has led to the development of a wide variety of third-party specific-purpose I/O boards that can be directly plugged into the top of any standard Arduino printed circuit board (PCB). These boards — which are called "shields"



■ FIGURE 1. PICAXE AXE401 Shield Base.



■ FIGURE 2. Arduino Diecimila.

in the Arduino world — all use special female headers with long "tails" so that it's possible to stack multiple shields on top of each other (with the main Arduino board on the bottom of the stack) to implement surprisingly complex systems.

However, for people who like to develop their own stripboard-based circuits (do you know anyone like that?), the Arduino system poses a major problem. If you look closely at the I/O headers on the Arduino board in **Figure 2**, you can see that the two headers on the top edge of the board are spaced more closely together than the two headers on the bottom edge of the board. The spacing of the bottom headers is "standard" in that there is exactly 0.1 inch between them.

As a result, the traces of a stripboard line up perfectly with the pins of the bottom two headers. However, that's not true for the top two headers. If you line up a stripboard's traces with the pins of either one of the headers, the traces will be out of line with the pins of the other header. As a result, it's extremely difficult to construct stripboard circuits for Arduino projects which has been a major frustration for me in the past.

Fortunately, the one difference in the AXE401's header layout (which I mentioned above) corrects this situation. If you again compare **Figures 1** and **2**, you'll see that the AXE401 has two (differently aligned) headers toward the left of the top edge of the board, where the Arduino board only has one. The extra header on the AXE401 duplicates the pins of the immediately adjacent header, and is perfectly aligned (on 0.1 inch centers) with the other three headers (the one on the top right and both headers on the bottom edge).

As a result, any shield that can be plugged into a standard Arduino board can also be plugged into the AXE401, and we can also make our own stripboard shields by simply ignoring the one misaligned header and using the four headers that are compatible with standard stripboard spacing. Therefore, the AXE401 makes it easy for experimenters to develop their own shields rather than relying solely on commercially available products. Later in this installment, we'll take advantage of that fact.

Two other differences between the Arduino board and the AXE401 are worth mentioning at this point. First, the Arduino includes many surface-mounted parts, while all the components on the AXE401 are the through hole variety. This makes it possible for RevEd to offer AXE401 kit versions as well as bare boards (in addition to the assembled and tested version), providing a wider range of choices for hobbyists. In addition, it simplifies the process of modifying the board to meet specific needs.

For example, in **Figure 1** I replaced the original reset switch with the red reset switch you can see protruding from the right side of the board, because I wanted to make the switch more accessible when a shield is installed on top of the AXE401. (The original switch was similar to switch S1 on the Arduino board in **Figure 2**.) Also, the USB interface (the surface-mounted IC in **Figure 2**) is included on every Arduino board. That's not necessary for the AXE401 because the PICAXE AXE027 USB cable includes the USB interface. As a result, an assembled and tested AXE401 is approximately half the price of an Arduino board.

There's a lot more to be said about the many features of the AXE401 Shield Base and its newly upgraded 28X2 processor. However, my main goal for this issue is to construct a breadboard shield for use with the AXE401, so I don't have enough space to present the details this month. We will, however, get into those details in future installments of the Primer. In the meantime, you may want to download and read the following two datasheets from Revolution Education:

- **PICAXE X2 Product Briefing (Dec. 2010 Update)**; available at **www.rev-ed.co.uk/docs/picaxex2.pdf**.
- **PICAXE-28X2 Shield Base (AXE401)**; available at **www.rev-ed.co.uk/docs/axe401.pdf**.

Before we move on to the fun part of this column, there's one aspect of the AXE401 that I do want to briefly discuss. RevEd designed the 401 to be compatible with the vast majority of Arduino shields that are currently available. Part of that

Shield Header	Shield Nickname	Primary Pin Function	Advanced Pin Function	PICAXE Pin Name	PICAXE ADC
RESET		Reset		Reset	
3V3		3.3V Supply Out		V+	
5V		5.0V Supply Out	5V Supply In	V+	
GND		0V	0V Supply In	0V	
GND		0V		0V	
VIN		Supply In (9-12V DC)			
A0	S.A0	In / Out / ADC / Touch	Comp1-	A.0	0
A1	S.A1	In / Out / ADC / Touch	Comp2-	A.1	1
A2	S.A2	In / Out / ADC / Touch	Comp2+ / DAC	A.2	2
A3	S.A3	In / Out / ADC / Touch	Comp1+ / Vref	A.3	3
A4	S.A4	In / Out / ADC / Touch		B.3	9
A5	S.A5	In / Out / ADC / Touch	hpwm D	B.4	11
0	S.0	In / Out / ADC / Touch	hserin / kb data	C.7	19
1	S.1	In / Out / ADC / Touch	hserout / kb clk	C.6	18
2	S.2	In / Out / ADC / Touch	hpwm B / hint 2	B.2	8
3	S.3	In / Out / ADC / Touch	pwm / hint0	B.0	12
4	S.4	In / Out / ADC / Touch	hpwm C / hint 1	B.1	10
5	S.5	In / Out / ADC / Touch	pwm	B.5	13
6	S.6	In / Out		B.6	-
7	S.7	In / Out		B.7	-
8	S.8	In / Out	timer clk	C.0	-
9	S.9	In / Out	pwm	C.1	-
10	S.10	In / Out / ADC / Touch	hpwm A / pwm	C.2	14
11	S.11	In / Out / ADC / Touch	hspi sdo	C.5	17
12	S.12	In / Out / ADC / Touch	hspi sdi / hi2c sda	C.4	16
13	S.13	In / Out / ADC / Touch (or LED via H4)	hspi sck / hi2c scl	C.3	4
GND		0V		0V	-
VREF	S.A3	In / Out / ADC / Touch	Comp1+ / Vref	A.3	3

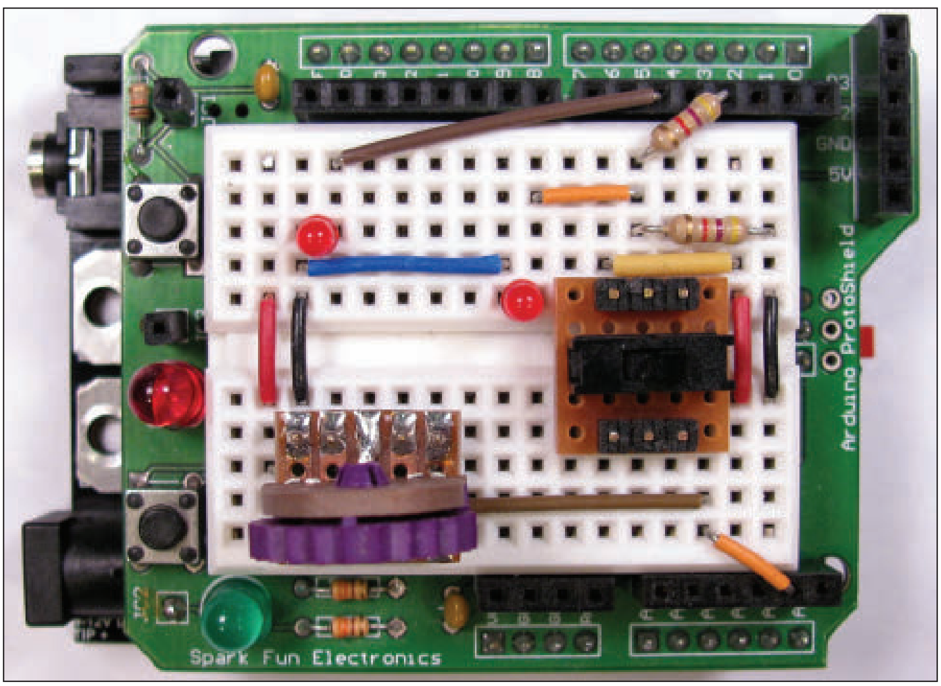
■ FIGURE 3. AXE401 Header Pin Mapping.

process involved carefully matching the function(s) of each 28X2's I/O pins with the already established pinout of the Arduino boards. **Figure 3** — which is taken directly from the AXE401 pdf file I just mentioned — presents the complete PICAXE/Arduino pin mapping for all the header pins. If you're not familiar with Arduino processors, they have 14 digital I/O pins (labeled 0 through 13), and six analog I/O pins (labeled A0 through A5). In the "Shield Nickname" column, the portion of each name that follows the "S." is the standard Arduino name for each pin.

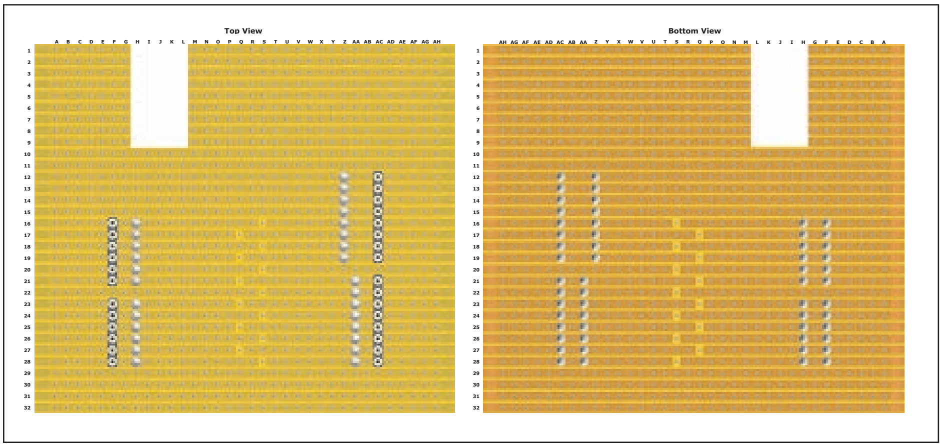
In other words, the nickname S.A0 is the Arduino A0 pin. If you are familiar with Arduino processors, you may prefer to use the nicknames rather than the PICAXE pin names. In order to provide that option, RevEd has recently modified the 28X2 compiler so that either naming convention can be used. For example, the statements "toggle C.5" and "toggle S.11" are both syntactically correct, and will toggle the state of the same header pin.

CONSTRUCTING A BREADBOARD SHIELD FOR THE AXE401

Okay, that's more than enough to get us started with the AXE401 – let's build something! Arduino prototyping shields are commonplace, and many experimenters use them to mount a small breadboard for project development. For example, **Figure 4** shows a breadboard that I attached to a SparkFun ProtoShield for the Arduino. Of course, now I can also insert the same shield into the AXE401, as you can see in the photo. However, the Arduino and PICAXE-28X2 are both powerful processors with many I/O lines, and I have always found it frustrating that no one seems to make a shield with a larger breadboard (e.g., the 400 point breadboard we have used in many of our Primer projects). Naturally, when I first learned of the availability of the AXE401 and the fact that standard stripboards can be used for developing shield projects, I began thinking about how to construct just



■ FIGURE 4. Typical Arduino Protoboard.



■ FIGURE 5. Stripboard Layout.

such a shield. I soon realized that there was a major obstacle to overcome.

A 400 point breadboard is wider than the span of the AXE401 (and Arduino) headers. Therefore, the headers on the shield that mate with the headers on the AXE401 would need to be soldered in place underneath the breadboard. Also, the breadboard needs to be flanked by female headers so that jumpers can easily connect to the processor's I/O lines. This means that the stripboard needs to be installed with its traces on the bottom, so that the female headers can be soldered in place. The problem was to figure out how to solder the male headers securely under the breadboard.

Of course, they could be reverse soldered, but then the breadboard would need to be raised to allow for the black plastic strip on the male headers which, in turn, would mean that the female headers would also have to be raised in some way. That approach seemed far too complicated to me, so I was determined to find a way to connect everything without having to raise the breadboard and female headers.

The simplest solution would be to reverse-solder the male headers and snip off the black plastic and the portion of each pin that would protrude from the top of the stripboard. However, I was fairly certain that wouldn't work because copper traces can be easily pulled off the surface of a stripboard. To test that assumption, I used that approach to solder a few pins to a scrap of stripboard; sure enough – it was surprisingly easy to pull the pin (and the trace) right off the board. So, I doubt that such a shield would survive very many insertions and extractions from the main board.

I tried a couple of other approaches that worked well but were tedious to implement. For example, pinching a small piece of a very thin wire around the protruding pin on the top of the stripboard, soldering the wire to the pin, and then snipping and sanding the top of the pin very close to the board made it impossible to pull the pin out from the bottom. However, it seemed like too much work to do all that for the 28 pins that are required!

It finally dawned on me that what I needed was a pin with a really small head. (That sounds like a straight pin, doesn't it?) It turns out that a #20 straight pin has a diameter of 0.025 inches which is exactly the same as a male header pin. The following procedure produces rock solid pins:

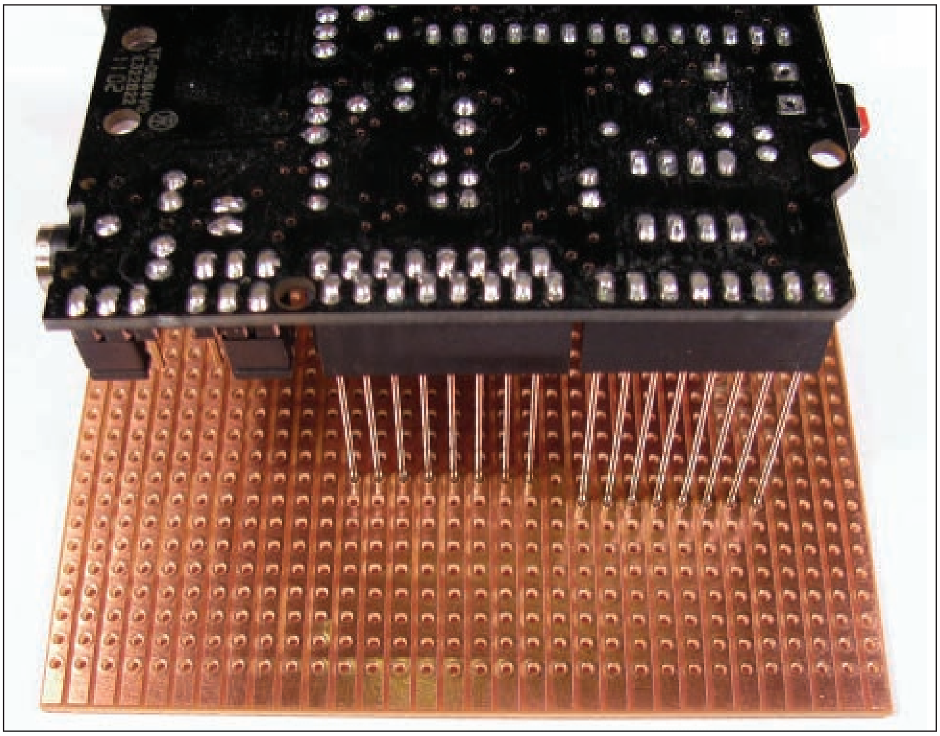
- Insert the straight pins from the top of the stripboard.
- Place a scrap of wood on top of the board, flip it over, and clamp it to a scrap of wood so that the pinheads are pressed tightly against the top of the stripboard.
- Reverse-solder the straight pins on the bottom of the board.
- Snip the pins to the desired length (approximately 1/4 inch).

Armed with that knowledge, I felt ready to tackle my breadboard shield project. **Figure 5** presents the stripboard layout that I used. (A full-size version is also available for downloading from the *Nuts & Volts* website.) The layout is very simple, but it's also somewhat larger than most of our previous projects. I used a large stripboard so that it would support the entire breadboard. However, only the 17 traces that contain header pins are really necessary. The cutout in the top-left quadrant is needed because the power connector on the AXE401 is slightly too high for the stripboard to sit flat on the 401's headers.

Of course, if you decide to use a small stripboard, you can avoid the cutout altogether because the small stripboard won't extend as far as the power connector. In either case (large or small stripboard), it's important to use the entire width of the board, including the area on each side that doesn't have holes in it. In other words, it's necessary to use the full 3.65 inch width of either size board. This is because we are going to use the extra width to include labels for each pin which will definitely make life easier.

Note: In order to construct the breadboard shield, it's best to actually have an AXE401 board on hand to make sure everything lines up correctly as you proceed. Also, you will need a total of eight headers: two straight eight-pin male headers; two straight six-pin male headers (the double-ended kind with pins that are long enough on both ends so that either end can be fully inserted in a breadboard, e.g., 0.23" & 0.32"); two straight eight-pin female headers; and two straight six-pin female headers. (I didn't have six-pin female headers, but they are simple to make by removing two pins from an eight-pin header and snipping/sanding the excess black plastic to size.) In addition, 28 straight pins are required (#20 size).

The following discussion may be



■ FIGURE 6. Aligning the Straight Pins.

easier to understand if you sneak a peek at the finished product shown in **Figure 11** before reading much further. The red reset switch on the left side of the shield isn't included in the following discussion because I didn't think of it until I had finished the entire project. However, it was a simple matter to add it to the finished board, which I'll mention at the end of this installment. When you're ready to construct the shield, just complete the following (somewhat lengthy) set of steps.

1.) Prepare the stripboard.

• Cut and sand your stripboard to size. If you are using the large stripboard, make the necessary cutout for the power connector.

• For either size board, don't forget to cut the traces between the pins on the left and right sides of the board. (Multiple shorts between I/O pins would definitely damage the processor!)

2.) Install the straight pins.

• Insert all 28 straight pins through the top of the stripboard in their correct positions as shown back in **Figure 5** (columns H, Z, and AA).

• Place a piece of scrap wood on top of the pinheads and invert the stripboard so that the pins are pointing up.

• Clamp the stripboard and scrap wood to a flat surface so that the pinheads are pressed tightly against the top of the stripboard (which, of course, is now on the bottom).

• In order to make sure the pins are aligned correctly before soldering them in place, invert the AXE401 and insert each straight pin into its mating header pin (see **Figure 6**). This isn't an easy process, and it can be frustrating at times. Doing one side completely before starting the other side helps a bit, and so does using needle-nose pliers rather than your fingers.

• When all the pins are fully inserted, make sure everything lines up correctly, and then solder each pin to the bottom of the stripboard, using as little solder as you can.

• When all the straight pins are soldered in place, use a 1/4 inch thick piece of Masonite or scrap wood as a guide, and snip all the pins to a length of 1/4 inch.

• You may also want to sand or file the ends carefully to remove any sharp burrs.

3.) Carefully align the header labels.

• **Figure 7** is a template for the header labels that we are going to affix to the top of the stripboard. (A full-size pdf file is available for downloading from the *Nuts & Volts* website.) When you print out the template, make sure it's exactly four inches wide; if not, adjust your print size until it is. You can trim it down to the size of the rectangle to make it easier to install. (We'll trim it to the exact size after we affix it to the stripboard.)

• Using a straight pin or small finishing nail, poke a hole in the center of each of the 28 circles immediately adjacent to each label name (columns F and AC). Do not poke holes in the other 28 circles that are closer to the center of the template.

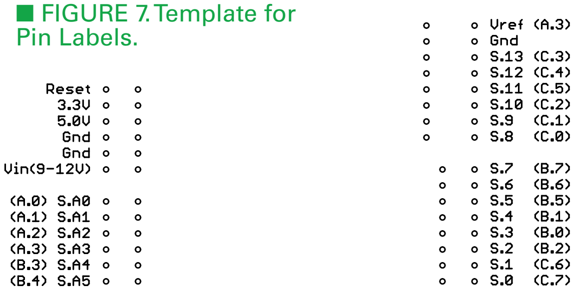
• Insert the longer ends of the two six-pin double-ended male headers into one breadboard and the longer ends of the two eight-pin double-ended male headers into the other breadboard as shown in **Figure 8**. This arrangement duplicates the position of the female headers in the stripboard layout.

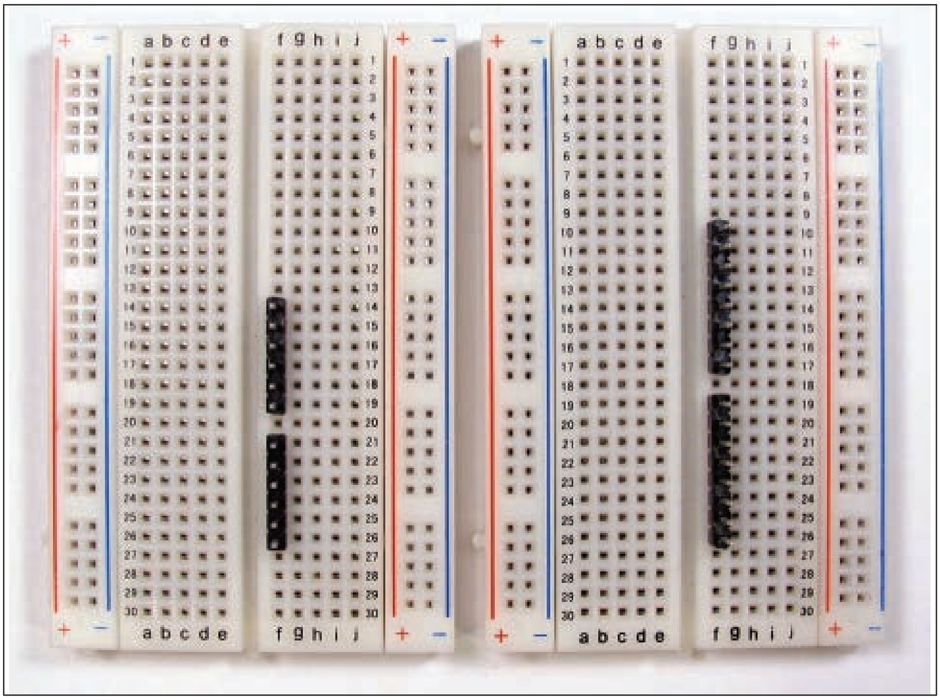
• Place the stripboard (right side up) on the pins so that the pins protrude through the correct holes in columns F and AC.

• Place the template on top of the protruding pins by carefully aligning the bottom hole on each side of the template with the bottom pin on each breadboard.

• When you are certain that

■ FIGURE 7. Template for Pin Labels.





■ FIGURE 8. Male Headers in Breadboards.

these two starting points are correctly aligned, gradually work your way up each column, pressing down as you go. I found that using a six-pin female header to gently press down helped me to avoid tearing the template.

• When all the pins are correctly aligned with all the holes (see **Figure 9**), carefully remove the stripboard and template from the pins, and set the template and the breadboards aside. (We're going to re-use the breadboards shortly.)

4.) Affix the labels to the top of the stripboard.

• Using a can of spray adhesive, follow the directions on the can to spray the top of the stripboard. I used the same spray adhesive (3M #45) that we used back in our "Faux PC Board" project (*Nuts & Volts*, June '08).

• Place the stripboard back on the male pins as before, making certain that the pins are in the exact same positions in columns F and AC, and then place the template back on top of the pinheads (again, in exactly the same position). Working carefully (once the template sticks to the stripboard, it's really stuck!), gradually press around the pins again with a female header until the entire template is firmly attached to the stripboard.

• Remove the stripboard and template, set it on a flat surface, and cover it with a piece of paper to protect against smudges.

• Thoroughly rub the entire surface to be sure the template is completely affixed to the stripboard.

• Flip the board over and use a utility knife to trim the template to the size of the stripboard.

• In order to protect the paper template from fraying over time, you may want to cover the left and right sides (from the inner columns of circles to the edge of the template) with strips of two inch clear packing tape.

Trim the tape so that it wraps around the edge of the stripboard and still has about a half an inch or so to stick on the bottom of the stripboard. It's probably better to not cover the center portion of the template with tape because the breadboard is likely to adhere better to the paper than to cellophane tape.

5.) Solder the female headers in place.

• Use a pin or finishing nail to poke the same 28 holes again, this time through the tape.

• Insert the four female headers (upside down, of course!) onto the tops of the corresponding male headers already positioned in the two breadboards, but this time reverse the position of the two breadboards so that the eight-pin headers are on the left side.

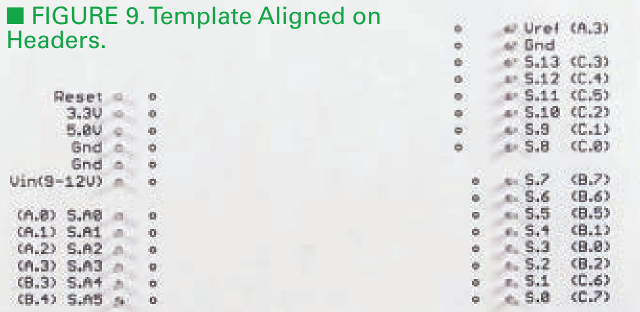
• Invert the stripboard (traces up) and again align the holes with the pins of the female headers.

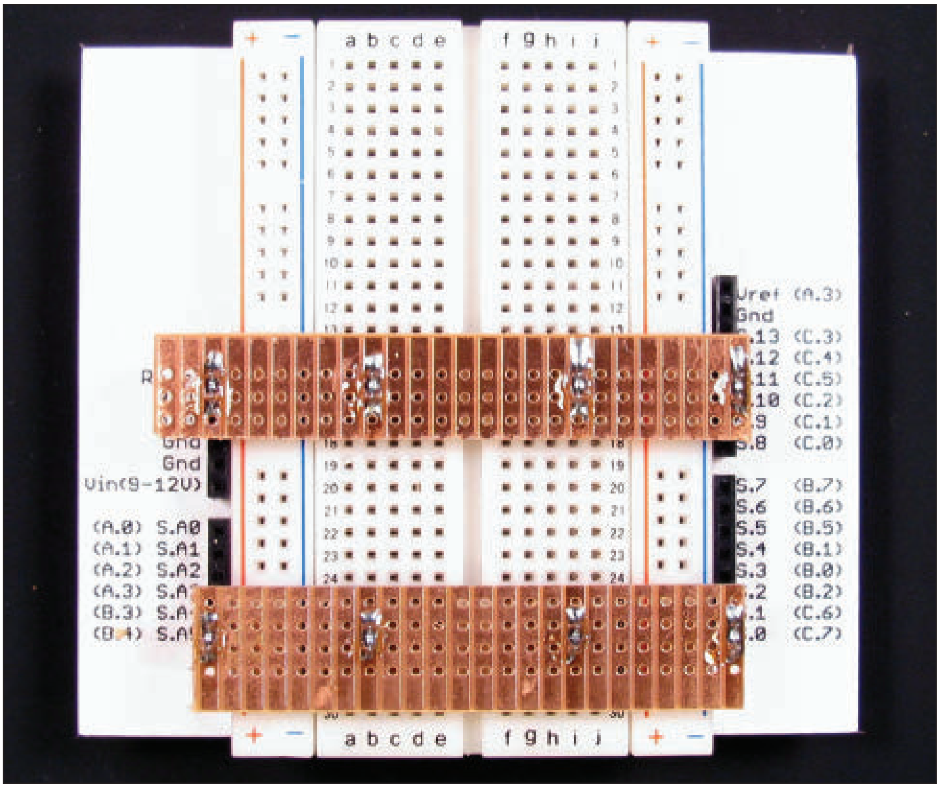
• When all the pins of the female headers are protruding through the correct holes and the headers are aligned properly, solder all the pins in place.

All that remains is to stick the breadboard in place between the two columns of female headers. Of course, you can simply "peel and stick," but in case you're like me (i.e., just a little bit compulsive), I'll tell you how I did it. Before I peeled the paper from the back of the breadboard and stuck it between the headers, I wanted to be sure to align the holes in the main portion of the breadboard with the holes in the headers. So, I made a simple jig from two scrap pieces of stripboard as shown in **Figure 10**.

In the photo, you can't see the AXE401 — which is below the breadboard shield — with the pins of the shield fully inserted into its female headers. After testing the fit to be sure everything lined up correctly, I removed the breadboard with the jig still attached, and peeled off the paper backing. Then, I gradually lowered the breadboard and jig back

■ FIGURE 9. Template Aligned on Headers.





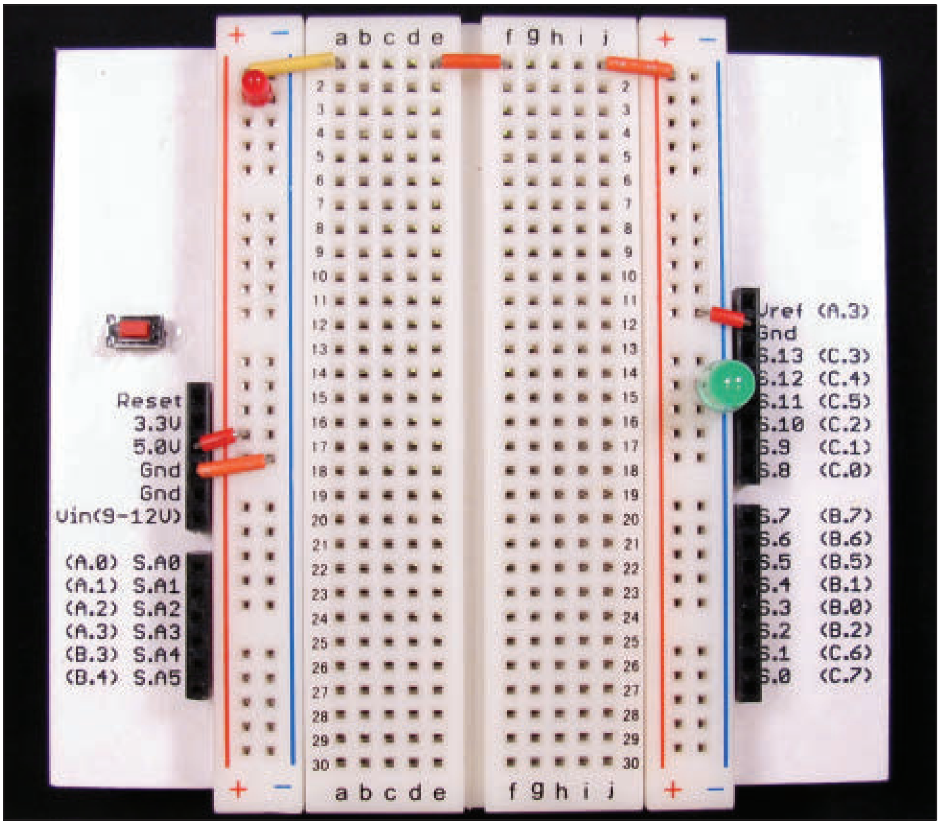
■ FIGURE 10. Jig for Aligning Breadboard.

onto the same pins I had just used.

Finally, I pressed the breadboard firmly into place, and removed the jig. The end result of all this work is shown in **Figure 11**, with a complete "Hello World" circuit in place (i.e., the green LED on the right). Note that jumpers are required to get the +5.0V connection (or +3.3V, if that's what you're using) from the left side to the right side of the breadboard, but not for ground because there's an available ground connection on both sides of the breadboard.

We're just about out of space this month, but I still need to explain the mysterious appearance of the reset switch. You probably remember that a PICAXE reset line needs to be held high in order for the processor to run a program. (There's a resistor on the AXE401 that does the job.)

To reset the processor, the reset line just needs to be briefly pulled low. Some time after I had completed the breadboard shield, it dawned on



■ FIGURE 11. Completed Breadboard Shield.

me that the easy availability of reset and ground traces on the stripboard would make it a snap to add a reset switch to the project, which would be much easier to access than the one on the AXE401. In fact, the entire modification took less than five minutes.

I'll leave this little project for you to figure out, but I will warn you about one possible problem. If you place the switch horizontally in the ground trace (as I did), don't forget to sever the trace between the switch's two pins. If you don't, the reset line will be permanently grounded, and the 28X2 will not function at all. (I imagine you can easily guess how I know that!)

That's it for this month, but we're not finished with the AXE401 yet. Plus, I haven't forgotten about my little capacitive-touch doormat project. See you next time. **NV**

Q&A

WHAT'S UP:

Join us as we delve into the basics of electronics as applied to every day problems, like:

- ✔ Rotary Switch Replacement
- ✔ USB Battery Charger
- ✔ Wireless Control

WITH RUSSELL KINCAID

In this column, I answer questions about all aspects of electronics, including computer hardware, software, circuits, electronic theory, troubleshooting, and anything else of interest to the hobbyist. Feel free to participate with your questions, comments, or suggestions. **Send all questions and comments to: Q&A@nutsvolts.com**

DC POWER FILTERING

Q I have a hybrid Klein 595 side scan sonar system and I'm trying to reduce the system noise. The sonar system transmits and receives 500 kHz sound pulses from transducers mounted on a towfish that is towed in the water. The system runs on 24 VDC or 120 VAC.

When running the system on 24 VDC, the 24 VDC is fed directly from two series batteries to a power supply (PS2) that provides ± 15 VDC, 5 VDC, and 750 VDC to the system.

When running the sonar on 120 VAC, I have the mains connected to a 06EB11 EMI filter, then a "Mean Well, TRC" PPS-125A-24 switching power supply (PS1) providing the 24 VDC to PS2.

When run on 24 VDC off the two batteries, I can increase the gain setting two to three steps higher than I can when I'm running the system on 120 VDC before I start to see noise. I've tried a few filtering techniques — which I don't know much about — to try and get the system to perform as well on 120 VAC as it does when run on 24 VDC (batteries), but I haven't had any luck.

I've tried .1 µF and 4,800 µF caps on the output; Viclan 4010 filters on the outputs. PS2 only draws 40 mA, so I added a 24 ohm resistor to the output to increase the load, but that didn't help. I'm thinking of trying a SNA-01-223 DC output filter for switching power supplies. Any other suggestions?

— Mark Munro

A Since the sonar system runs best on batteries, the solution may be to always run on batteries. PS1 can be used to keep the battery charged. I would put an inductor (Mouser part number 542-2100HT-102H-RC would be good) in series between PS1 and the battery to limit noise. The Cosel filter would be good also. If that doesn't work, the problem may be radiation from PS1. If it is not already in a metal box, put it in one. If those things don't work, you have a unique problem and I don't have a solution.

PROGRAMMING HELP

Q I'm working on a project that I developed with the Parallax Professional development board using the BS2, rev J PIC. I am a "newbie" in this digital realm of PIC controllers, often designing projects that are not uC controlled. I am close to completion, but am unsure about putting my design onto a stand-alone circuit board.

I suspect that any firmware changes will require an on-board programming port. Can you provide some of this information and/or direct me to resources to help me?

— John Abbott

A For me to advise you would be the blind leading the blind. Although I have been programming in Basic for 50 years, I have only been working with PICs for several years; self-taught. I did buy a BS2 years ago and wrote a few programs, but decided it was not versatile enough and I now program PICs directly using PICBASIC PRO and melabs' U2 programmer (**www.melabs.com**).

That said, I did some research at **Parallax.com** and found that the BS2 rev J has three dedicated programming pins (pins 1, 2, 3). I believe that you can program the BS2 in-circuit at any time using those pins, as described in the documentation. For more detailed help, I suggest the Parallax forums: **http://forums.parallax.com/forum.php**.

POWER FROM SPRING RUNOFF

Q I live on the side of a mountain and I would like to generate electrical power from water runoff without creating a dam. I have a two to four foot relief tube under the road that really runs in the Spring. The design would have to be low cost as runoff is obviously time limited. Some type of water wheel or

in-line venturi, micro-hydro power system appears to be the answer. Any suggestions on how to proceed?

By the way, we get very high winds here due to our proximity to Mt. Washington, NH. I have looked at a windmill but I believe it to be too much maintenance.

I do heat my hot water by evacuated solar tubes and yes, they do really work here in New Hampshire, at least above 20 degrees!

— Howard Epstein

A I am intrigued by your question because I have a similar situation where water runs out of the hillside. The problem is that to produce power, there has to be pressure or velocity. The water coming out of the tube has neither. If you block the tube to produce pressure, the water will just find another path.

The solution is to direct the water to a penstock tube which goes downhill for 10 or more feet of vertical drop (less than 10 feet is probably not worth the effort). Now, you have the needed head and can put a nozzle at the bottom to operate a pelton wheel, or insert a turbine to generate power.

You will find many sites on the Internet describing homemade turbines. Here is one: **www.ehow.com/how_5256700_build-homemade-water-turbine-generator.html** and another: **www.builditsolar.com/Projects/Hydro/BANKITUR.pdf**. If you use an automotive alternator to charge a 12 volt battery, you will want to turn it several thousand RPM. I hope this has been helpful; good luck with your project.

ROTARY SWITCH REPLACEMENT

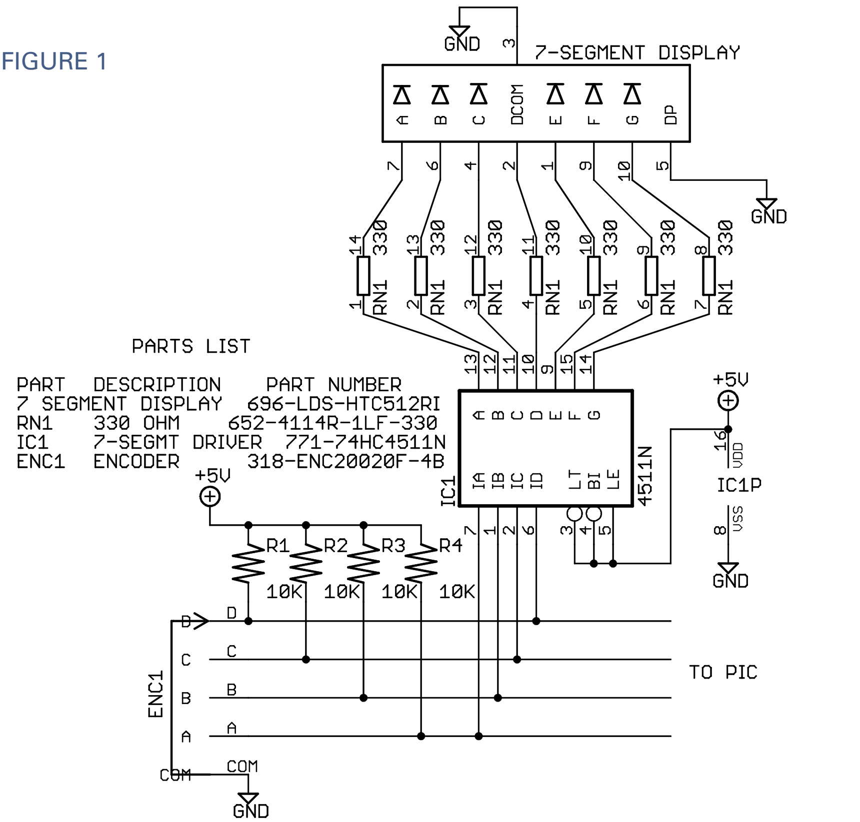
Q I'm a new reader to *Nuts & Volts* and I'm an old timer learning new tricks. I have an application that is using an eight position rotary switch to select eight different modes. Ground is the center pole and this turns on eight inputs to a PIC microprocessor; all kinds of things happen after that. What I would like to do is replace the rotary switch with a normally open pushbutton and use a seven-segment display to select which mode I want.

I think the first step is to build a switch debouncer using an SN74HC002N but I'm not sure if I'm heading in the right direction here or not. Can this project even be done? Thanks!

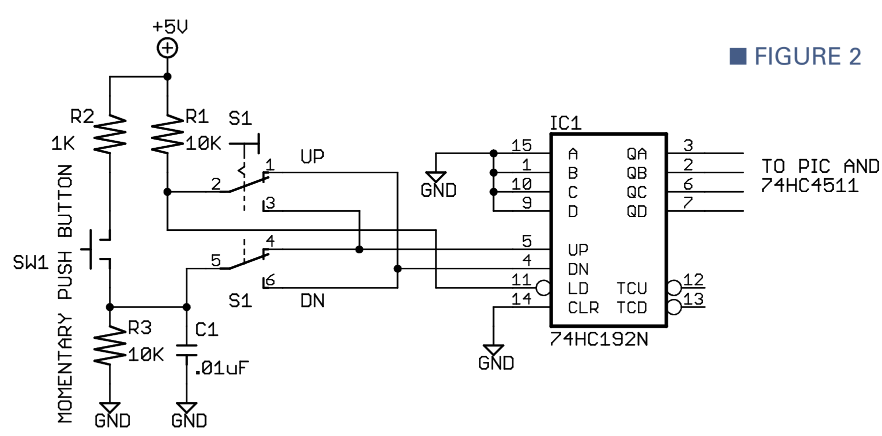
— Paul Horton III

A Yes, you need a debouncer; a capacitor across the contacts normally does the job. You could use a rotary encoder. The one I have used is similar to a rotary switch except it has 16 positions and outputs a binary code on four wires (gray code is also available). Mouser part number is 318-ENC20020F-4B. You would use a seven-segment

■ FIGURE 1



■ FIGURE 2



decoder chip to drive the display, (see **Figure 1**). Alternatively, you could use a four-bit counter and clock it with the pushbutton switch (see **Figure 2**).

In **Figure 1**, the encoder symbol does not represent how it works because I don't know how it works. The advantage is that four inputs to the PIC are freed up for other uses; the downside is you have to decode the number in software. In **Figure 2**, I have provided an up/down switch, but if you don't mind going to 10 to get back to 1, you could eliminate the switch and always count up (or down).

USB BATTERY CHARGER

Q I always like to read your magazine since I'm a hobby robot builder and like to solder.

For my new project, I want to build a solar charger with a female USB connector to charge my cellphone, iPod, etc.

Do you know of any circuit that regulates the voltage coming from the solar panels to the common voltage of USB chargers? Which USB connections are the ones I have to use to charge my device?

— Andy W.

A The only regulation needed is to limit the voltage from the solar collector using a five volt zener diode across the terminals. The USB charger provides five volts on pins 1 and 4; pin 1 is positive. See the diagram in **Figure 3**. If the socket has five terminals, the fourth one is not used and #5 is #4.

UNKNOWN IC

Q I have this schematic (not my design) that I got through classified mail order in 1988. It is of a voice pitch changer using a dual SAD1024 and this unknown chip, the TL057. I have not been able to find any data on the TL057. Can you give me any equivalent number for the SAD1024 or TL057? The schematic shows two pin 3 on the TL057, but can the logic tell you anything?

— Craig Kendrick Sellen

A The 4027 (the 4027 is a dual J-K flip-flop) also has two pin 3. The schematic is too screwed up to be of any use. The 4027 output is logic, feeding the TL057 which drives the second half of the 4027. There is no point to it unless it is a variable delay. TI does not acknowledge ever making a TL057.

The SAD1024 is a bucket brigade analog delay line. It is obsolete and there is no direct replacement. You can find the IC on eBay but the price is high. I found some SAD512 which is equal to 1/2 SAD1024, and there are other bucket brigade ICs available.

GM REMOTE KEY FOB CIRCUIT

Q I have two GM remote key FOBs that have quit functioning. Their part numbers are: GM15186200 and GM15186201 FCCID LHJ011.

I also have a Motorola IC 40209Y02 with another code of XAA221 on it.

I am trying to find the following for this key FOB:

1. Replacement IC.
2. Pin-out.
3. Circuit for my three button key FOB.
4. What the cylinder device is that is located to the right of the IC ... crystal?

If it is an XTAL, what is the frequency? Who would stock a replacement?

Can you shed any light on how to proceed?

The thought of paying a dealer $100+ per key FOB plus programming charges of $100 is outrageous.

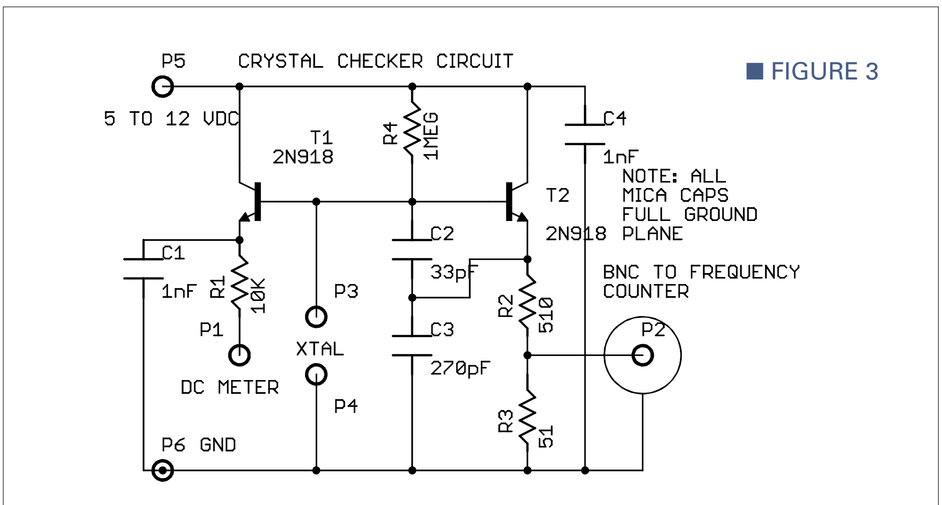
I already know how to re-sync the key FOB and how to program it. A replacement IC can't cost that much if I can locate the part.

— Larry Kraemer

A You can inquire of Motorola but I am sure they will tell you that this is a proprietary design for GM and you can only buy it from GM.

There are shops that specialize in installing remotes; they may be able to hack the system to use one of their remotes. Otherwise, I think you are stuck paying the price or using the key.

That cylindrical device is likely a crystal; you can find the frequency by putting it in a crystal checker and measuring the frequency. The shunt



■ FIGURE 3

MAILBAG

Dear Russell: Re: Linux and PIC, March '11, page 28.

I was looking through the Q&A section of *Nuts & Volts* in the March issue, and one of the readers asked about programming PICs through Linux. Microchip is currently rewriting MPLAB in NetBeans with the new MPLAB X (as it's called) to be released this summer. The new MPLAB X will work with Linux, Windows, and Mac machines.

Here's a link to the beta: **http://ww1.microchip.com/downloads/mplab/X_Beta/index.html**. I personally have run it on Ubuntu and it works great.

It would be good to let the user know that he can get the PICkit3 programmer for $50 and it will be compatible with MPLAB X. His life is going to get a lot easier in a few months.

P.S. I am not in any way affiliated with Microchip, just in case anybody cares.

— Jorge Garcia

Response: Thanks for the feedback, Jorge. I am sure many will find this interesting.

Dear Russell: Re: Power Supply, March '11, page 26.

In the power supply question, you discuss the parameters of the power transformer. From the number of test turns and the resulting inductance, you deduce the parameter Al (mH/1000T). You state this result as Al=0.3099 mH/1000T. I suspect the numerical value stated is actually H/1000T.

I am in the process of designing a similar sort of power supply and thought I would use your answer as a check. I calculate your Al as 309.9 mH/1000 turns. Gremlins in the zeros?

— Ernie Moore

Response: You are right, Ernie. I should remember to check that the answer is reasonable rather than blindly accept it. Thanks for writing. Luckily, my other numbers are okay.

capacitance will affect the frequency so you should measure the caps in the circuit and use the value in the checker circuit. See the crystal checker circuit diagram in **Figure 3**.

You can find someone on the Internet who will make a custom frequency crystal. I had some made years ago at a cost of $10 each (Bomar Crystal Co.; they are still in business; I don't know if they still do custom frequencies).

WIRELESS CONTROL

Q My question concerns a question I wrote about previously — how to repair the wireless control for a garage door opener. I've received enthusiastic response from several readers. Unfortunately, any suggestions I've been able to apply have not been successful. The electronics in my controller is pretty old.

Are there companies that market wireless remote/receiver combinations that only create a momentary contact closure on demand? I think that would solve my problem. The rest of the opener operates okay.

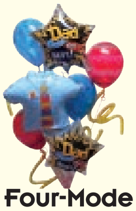
— Paul Kaltenborn

A I found a site selling a single channel remote control (transmitter $15, receiver $33 plus shipping); try **www.smarthome.com/70400/1-Button-Wireless-Transmitter-SK-919TD1S-UP-/p.aspx and www.smarthome.com/7046/1-Channel-RF-Receiver-Wireless-Receiver-for-RF-Remote-Control-SK-910R/p.aspx**.

Also, on eBay, I found a China source for a transmitter and receiver; $14.95, shipping included, eBay number 250672088996.

They have sold over 200 and eBay would have kicked them off if there were a lot of complaints, so I think this is a good deal.

Addendum: I got feedback from Paul; he ordered the China item. It was a four channel transmitter and receiver; one channel was intermittent and there was no documentation. He is still looking for a solution to his problem. **NV**



For Dads and Grads!

We Put The FUN In Electronics!

Four-Mode Keyless Entry Test Set

NEW!

- ✔ **Troubleshoot vehicular keyless entry and wireless remote control systems!**
- ✔ **Detects and verifies key fob to vehicle signals as well as vehicle to key fob signals!**
- ✔ **Separate visual indicators for the presence of 315/433MHz, 125kHz, 20kHz and IR signals!**
- ✔ **Can also test virtually any wireless IR/RF control and building access systems!**
- ✔ **Can even test household and home entertainment IR remote controls for the presence of IR signal output!**

Ahh!!... the conveniences of today's technology in our modern world! Voice recognition, LED's instead of incandescent bulbs, on-board computers, on-board hard drives, automatic parallel parking, automatic radar cruise control, and of course, wireless remote controls! They make it so simple, just have the "key" (called a key fob) somewhere in your pocket or purse, get near the vehicle, it knows that you are there! Touch the door handle and the vehicle unlocks. Get in and touch the start button and the vehicle starts. You have yet to use a key through the whole process! And don't forget all the wireless controls for your house lights, building access and entertainment systems. They're so great… until they don't work!

Just like the days of "plugs, points, and condenser" are over, so are the days of having the hardware store grind out a spare key for your car! Now when your keyless access system doesn't work, you need to accurately detect what part of the system is malfunctioning. This could be anything from a dead battery in the key fob, a "brain-dead" key fob, to malfunctioning sensors, antennas, or other system components in the vehicle. The WCT3 is designed for both the car dealer service shops as well as the consumer. Until now there was no way to determine where the system was failing. Please note that the WCT3 simply verifies the generation of the control signals. Indication of signal presence is not an indication the encoded data is valid, nor is it a reader of that code, so don't worry, this will not help anyone steal your car!

First, let's cover a few basics about vehicular keyless entry. In general, (not all systems are created equal), the vehicle itself generates a signal at 125 kHz or 20kHz. This is the signal that is used to "talk" to your individual key fob. Upon receiving the signal, your key fob "returns" a 315MHz signal uniquely encoded with an identification code and unlock command. If the embedded codes of the vehicle and your key fob match, you're in! Once you have "unlocked" the vehicle, and are inside the vehicle, the presence of your key fob is detected in the same way when the "start" button is pressed. If the codes match, the vehicle can be started. Some manufacturers also use Infrared (IR) signals in their key fobs to add additional user control functions to the vehicle. In that case, the key fob generates a modulated IR signal that is received by the vehicle's IR detectors placed throughout the perimeter of the vehicle.

Testing your system is easy. To test the complete 125 kHz/315 MHz communications path just stand close to the vehicle with the WCT3 and your key fob in hand. Press the test button and the WCT3 will detect and display the presence of the vehicle's 125kHz/20KHz signal and, if they "handshake", will also detect and display the presence of your key fob's 315MHz return signal. You can independently test key fob only signals (panic, lock, trunk, etc.) by holding the key fob near the WCT3, pressing the test button, and pushing the function button on the key fob. The same functionality testing can be done with IR key fobs. The modulated IR signal is detected and will illuminate the IR test LED on the test set. If you know a few "secrets" you can also see if the tire pressure sensors/transmitters are generating signals or the built-in garage door opener in your rear view mirror is transmitting a signal! But the WCT3's uses go beyond the automotive world. The majority of building wireless access systems also utilize 125 kHz. Just hold the test set near the building access sensor and the WCT3 will detect the 125 kHz signal. That will help you troubleshoot door access locations that are not working. It gets even better... you can use the WCT3 to test virtually any other 315 MHz, 433 MHz, 125kHz, 20kHz and IR wireless control system to verify generation of a signal. We should rename this "the handy-dandy, universal, wireless remote control tester"!

The WCT3 test set is housed in a compact 2.25" x 4.6" x 9" case and is powered by a standard 9VDC battery. The test set is available as a do-it-yourself hobby kit or factory assembled and tested. For the kit builder, the WCT3 contains both SMT and through-hole components, with 170 solder points. If you're a car dealer, independent service shop, or simply an owner of a newer vehicle with keyless entry, or have wireless entertainment controls you can't afford not to have a WCT3!

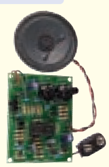
WCT3	**Four-Mode Keyless Entry Test Set Kit**	**$59.95**
WCT3WT	**Four-Mode Keyless Entry Test Set, Factory Assembled & Tested**	**$99.95**

Digital Voice Changer

This voice changer kit is a riot! Just like the expensive units you hear the DJ's use, it changes your voice with a multitude of effects! You can sound just like a robot, you can even ad vibrato to your voice! 1.5W speaker output plus a line level output! Runs on a standard 9V battery.

MK171	**Voice Changer Kit**	**$14.95**

Steam Engine & Whistle



Simulates the sound of a vintage steam engine locomotive and whistle! Also provides variable "engine speed" as well as volume, and at the touch of a button the steam whistle blows! Includes speaker. Runs on a standard 9V battery.

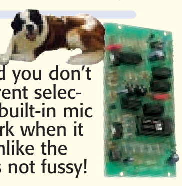
MK134	**Steam Engine & Whistle Kit**	**$11.95**

Laser Trip Senser Alarm

True laser protects over 500 yards! At last within the reach of the hobbyist, this neat kit uses a standard laser pointer (included) to provide both audible and visual alert of a broken path. 5A relay makes it simple to interface! Breakaway board to separate sections.

LTS1	**Laser Trip Sensor Alarm Kit**	**$29.95**

Electronic Watch Dog



A barking dog on a PC board! And you don't have to feed it! Generates 2 different selectable barking dog sounds. Plus a built-in mic senses noise and can be set to bark when it hears it! Adjustable sensitivity! Unlike the Saint, eats 2-8VAC or 9-12VDC, it's not fussy!

K2655	**Electronic Watch Dog Kit**	**$39.95**

The Learning Center!

Beginners To Advanced... *It's Fun!*

- ✔ **Learn and build!**
- ✔ **130, 200, 300, & 500 in one electronic labs!**
- ✔ **Practical through hole and SMT soldering labs!**
- ✔ **Integrated circuit AM/FM radio lab!**
- ✔ **Fuel Cell, Solar Hydrogen, and Bio-Energy labs!**
- ✔ **Beginner's non-soldering kits!**

For over 3 decades we've become famous for making electronics fun, while at the same time making it a great learning experience. As technology has changed over these years, we have continued that goal!

PL130A Gives you 130 different electronic projects together with a comprehensive learning manual describing the theory behind all the projects.

PL200 Includes 200 very creative fun projects and includes a neat interactive front panel with 2 controls, speaker, LED display and a meter.

PL300 Jump up to 300 separate projects that start walking you through the learning phase of digital electronics.

PL500 The ultimate electronics lab that includes 500 separate projects that cover it all, from the basics all the way to digital programming.

SP3B Whether young or old, there's always a need to hone your soldering skills. Either learn from scratch or consider it a refresher, and end up with a neat little project when you're done!

SM200K Move up to Surface Mount Technology (SMT) soldering, and learn exactly how to solder those tiny little components to a board!

AMFM108K We not only take you through AM and FM radio theory but we guide you through IC's. When you're done you've built yourself an IC based AM/FM radio that works great!

KNS10 With a reversible PEM fuel cell that combines electrolysis and power conversion into a single device you end up building your own fuel cell car! Learn tomorrows technology today!

KNS11 Learn alternative fuel technology while you build your own H-Racer car and refueling station!

KNS13 Convert ethanol alcohol to run a PEM fuel cell and watch it all work in front of your eyes!

KNS1 A great beginner's kit for the dinosaur enthusiast in the family, young and old! A wooden hobby kit that teaches motor and gear driven operation that requires no soldering.

PL130A	**130-In-One Lab Kit**	**$39.95**
PL200	**200-In-One Lab Kit**	**$69.95**
PL300	**300-In-One Lab Kit**	**$89.95**
PL500	**500-In-One Lab Kit**	**$219.95**
SP1A	**Through Hole Soldering Lab**	**$9.95**
SM200K	**SMT Practical Soldering Lab**	**$22.95**
AMFM108K	**AM/FM IC Lab Kit & Course**	**$34.95**
KNS10	**Fuel Cell Car Science Kit**	**$82.95**
KNS11	**H-Racer & Refueling Station Kit**	**$144.95**
KNS13	**Bio-Energy Fuel Cell Kit**	**$129.95**
KNS1	**Tyrannomech Motorized Kit**	**$17.95**

Digital Controlled FM Stereo Transmitter

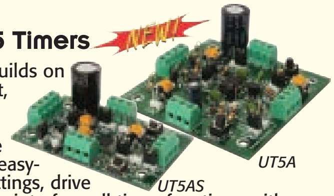
- ✔ **PLL synthesized for drift free operation**
- ✔ **Front panel digital control and display of all set tings and parameters!**
- ✔ **Professional metal case for noise-free operation**
- ✔ **EMI filtering on audio and power inputs**
- ✔ **Super audio quality, rivals commercial broadcasts**
- ✔ **Available in domestic kit or factory assembled export versions**

For nearly a decade we've been the leader in hobbyist FM radio transmitters. We told our engineers we wanted a new technology transmitter that would provide FM100 series quality without the advanced mixer features. They took it as a challenge and designed not one, but TWO transmitters! The FM30 is designed using through-hole technology and components and is available only as a do-it-yourself kit with a 25mW output very similar to our FM25 series. Then the engineers redesigned their brand-new design using surface mount technology (SMT) for a very special factory assembled and tested FM35WT version with 1W output for our export only market!

All settings can be changed without taking the cover off! Enter the setup mode from the front panel and step through the menu to make all of your adjustments. A two line LCD display shows you all the settings! In addition to the LCD display, a front panel LED indicates PLL lock so you know you are transmitting. Besides frequency selection, front panel control and display gives you 256 steps of audio volume (left and right combined) as well as RF output power. A separate balance setting compensates for left/right differences in audio level. In addition to settings, the LCD display shows you "Quality of Signal" to help you set your levels for optimum sound quality. And of course, all settings are stored in non-volatile memory for future use! Both the FM30 and FM35WT operate on 13.8 to 16VDC and include a 15VDC plug-in power supply. The stylish black metal case measures 5.55"W x 6.45"D x 1.5"H. Call for FM35BWT export information. *(Note: After assembly of this do-it-yourself hobby kit, the user is responsible for complying with all FCC rules & regulations within the US, or any regulations of their respective governing body. FM35BWT is for export use and can only be shipped to locations outside the continental US or valid APO/FPO addresses or valid customs brokers for end delivery outside the continental US.)*

FM30B Digital Controlled FM Stereo Transmitter Kit, 0-25mW, Black $199.95

Ultimate 555 Timers NEW!



This new series builds on the classic UT5 kit, but takes it to a whole new level! You can configure it on the fly with easy-to-use jumper settings, drive relays, and directly interface all timer functions with onboard controls or external signals.

All connections are easily made though terminal blocks. Plus, we've replaced the ceramic capacitor of other timer kits with a Mylar capacitor which keeps your timings stable over a much wider range of voltages! Available in through hole or surface mount versions! Visit www.ramseykits.com for version details.

UT5A Through Hole 555 Timer/Osc Kit $24.95
UT5AS SMT 555 Timer/Osc Kit $26.95

OBDII *CarChip Pro*

The incredible OBDII plug-in monitor that has everyone talking! Once plugged into your vehicle it monitors up to 300 hours of trip data, from speed, braking, acceleration, RPM and a whole lot more. Reads and resets your check engine light, and more!

8226 CarChip Pro OBDII Monitor-Asmb $79.00

RF Preamplifier

The famous RF preamp that's been written up in the radio & electronics magazines! This super broadband preamp covers 100 KHz to 1000 MHz! Unconditionally stable gain is greater than 16dB while noise is less than 4dB! 50-75 ohm input. Runs on 12-15 VDC.

SA7 RF Preamp Kit $19.95

Touch Switch

Touch on, touch off, or momentary touch hold, it's your choice with this little kit! Uses CMOS technology. Actually includes TWO totally separate touch circuits on the board! Drives any low voltage load up to 100mA. Runs on 6-12 VDC.

TS1 Touch Switch Kit $9.95

Doppler Direction Finder

Track down jammers and hidden transmitters with ease! 22.5 degree bearing indicator with adjustable damping, phase inversion, scan and more. Includes 5 piece antenna kit. Runs on 12VDC vehicle or battery power.

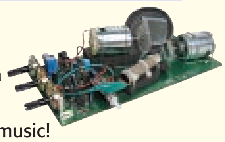
DDF1 Doppler Direction Finder Kit $169.95

Mad Blaster Warble Alarm

If you need to simply get attention, the "Mad Blaster" is the answer, producing a LOUD ear shattering raucous racket! Super for car and home alarms as well. Drives any speaker. Runs on 9-12VDC.

MB1 Mad Blaster Warble Alarm Kit $9.95

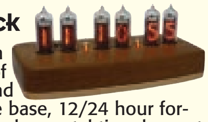
Laser Light Show



Just like the big concerts, you can impress your friends with your own laser light show! Audio input modulates the laser display to your favorite music! Adjustable pattern & speed. Runs on 6-12VDC.

LLS1 Laser Light Show Kit $49.95

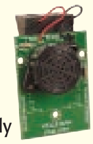
Retro Nixie Tube Clock



Genuine Nixie tubes popular in the 50's brought back in one of the neatest digital clocks around today! Hand made teak maple base, 12/24 hour format, soft fade-out, auto-dim, and a crystal time base at 20ppm! Tube kits also available.

IN14TM Teak Maple Nixie Clock Kit $329.95

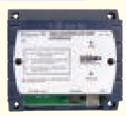
Water Sensor Alarm



This little $7 kit can really "bail you out"! Simply mount the alarm where you want to detect water level problems (sump pump)! When the water touches the contacts the alarm goes off! Sensor can even be remotely located. Runs on a standard 9V battery.

MK108 Water Sensor Alarm Kit $6.95

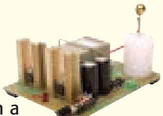
USB DMX Interface



Control DMX fixtures with your PC via USB! Controls up to 512 DMX channels each with 256 different levels! Uses standard XLR cables. Multiple fixtures can be simply daisy chained. Includes Light Player software for easy control. Runs on USB or 9V power.

K8062 USB DMX Interface Controller Kit $67.95

HV Plasma Generator



Generate 2" sparks to a handheld screwdriver! Light fluorescent tubes without wires! This plasma generator creates up to 25kV at 20kHz from a solid state circuit! Build plasma bulbs from regular bulbs and more! Runs on 16VAC or 5-24VDC.

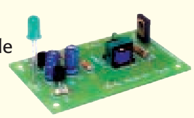
PG13 HV Plasma Generator Kit $64.95

Air Blasting Ion Generator

Generates negative ions along with a hefty blast of fresh air, all without any noise! The steady state DC voltage generates 7.5kV DC negative at 400uA, and that's LOTS of ions! Includes 7 wind tubes for max air! Runs on 12-15VDC.

IG7 Ion Generator Kit $64.95

Tickle-Stick Shocker



The kit has a pulsing 80 volt tickle output and a mischievous blinking LED. And who can resist a blinking light and an unlabeled switch! Great fun for your desk, "Hey, I told you not to touch!" Runs on 3-6 VDC.

TS4 Tickle Stick Kit $12.95

Speedy Speed Radar Gun

Our famous *Speedy* radar gun teaches you doppler effect the fun way! Digital readout displays in MPH, KPH, or FPS. You supply two coffee cans! Runs on 12VDC or our AC125 supply.

SG7 Speed Radar Gun Kit $69.95

Tri-Field Meter Kit

THE GHOST DETECTOR!

"See" electrical, magnetic, and RF fields as a graphical LED display on the front panel! Use it to detect these fields in your house, find RF sources, you name it. Featured on CBS's Ghost Whisperer to detect the presence of ghosts! Req's 4 AAA batteries.

TFM3C Tri-Field Meter Kit $74.95

Passive Aircraft Monitor

The hit of the decade! Our patented receiver hears the entire aircraft band without any tuning! Passive design has no LO, therefore can be used on board aircraft! Perfect for airshows, hears the active traffic as it happens! Available kit or factory assembled.

ABM1 Passive Aircraft Receiver Kit $89.95

Broadband RF Preamp

Need to "perk-up" your counter or other equipment to read weak signals? This preamp has low noise and yet provides 25dB gain from 1MHz to well over 1GHz. Output can reach 100mW! Runs on 12 volts AC or DC or the included 110VAC PS. Assmb.

PR2 Broadband RF Preamp $69.95

Electret Condenser Mic

This extremely sensitive 3/8" mic has a built-in FET preamplifier! It's a great replacement mic, or a perfect answer to add a mic to your project. Powered by 3-15VDC, and we even include coupling cap and a current limiting resistor! Extremely popular!

MC1 Mini Electret Condenser Mic Kit $3.95

Sniff-It RF Detector Probe

Measure RF with your standard DMM or VOM! This extremely sensitive RF detector probe connects to any voltmeter and allows you to measure RF from 100kHz to over 1GHz! So sensitive it can be used as a RF field strength meter!

RF1 Sniff-It RF Detector Probe Kit $27.95

3-In-1 Multifunction Lab

The handiest item for your bench! Includes a RoHS compliant temp controlled soldering station, digital multimeter, and a regulated lab power supply! All in one small unit for your bench! It can't be beat!

LAB1U 3-In1 Multifunction Solder Lab $134.95

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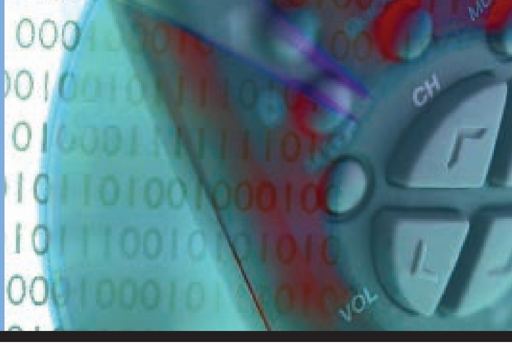
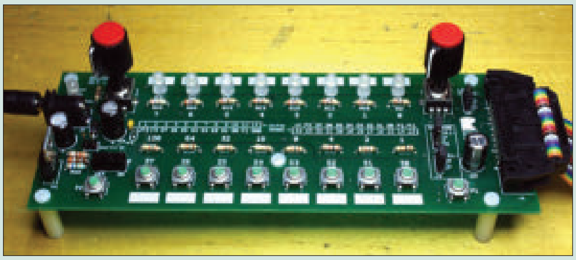


NEW PRODUCTS

- HARDWARE
- SOFTWARE
- GADGETS
- TOOLS

GENERAL-PURPOSE **BREADBOARD DEV KIT**

The Circuit Slices Breadboard Dev Lab is a tool that transforms a solderless breadboard into a general-purpose development system. The Dev Lab's power supply, pushbuttons, LEDs, and potentiometers — together with a breadboard — make an inexpensive and flexible development system for projects using microprocessors, microcontrollers, or discrete logic.



The Dev Lab brings the switches, LEDs, pots, and power supply off the design breadboard in a typical layout. This allows the developer more time to devote to the core design and to software development. The Dev Lab links I/O and power to a breadboard using a ribbon cable terminated with a 24-pin DIP header. The Dev Lab is 6.75" wide by 2.5" deep.

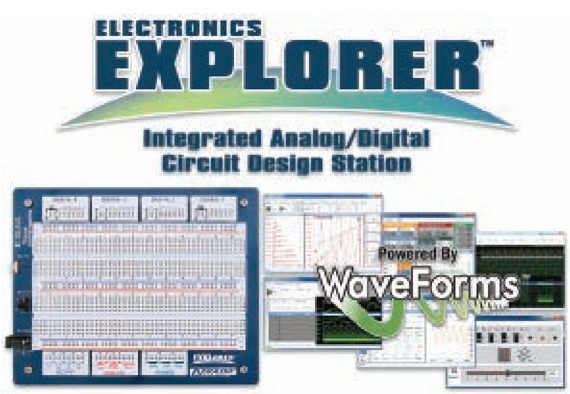
The kit comes with a high quality PCB and all board-mounted parts. The kit also includes an assembled and tested ribbon cable assembly. A wall-mount power supply and solderless breadboard are sold separately.

For more information, contact:
Circuit Slices
Web: **www.circuitslices.com**

ELECTRONICS EXPLORER KIT

Digilent, Inc., announces the launch of the Electronics Explorer Board (EE Board) — a powerful, all-in-one personal circuit design station. The EE Board is an affordable product designed for students, hobbyists, and engineering professionals, and includes everything needed to build and test a wide range of analog and digital circuits right on the desktop, without the need for any other equipment.

Priced for personal ownership, the EE Board provides students unlimited access to real hardware and software tools to design, simulate, test, and observe real circuits. Without the restriction of a traditional university lab setting, students can spend more time experimenting with real circuits and building knowledge through direct observation and experience.



The EE Board incorporates a solderless breadboard, a triple-output programmable power supply, a suite of test and measurement devices, and a high speed USB2 port to connect to the users' own PC. The station works in conjunction with WaveForms™ — a free software product that provides intuitive and easy to use interfaces to EE Board test and measurement devices.

Using only the EE Board and accompanying instrument pack, a wide variety of circuits can be constructed and tested by connecting to any one of the six included test and measurement devices, including: four-channel 40 MSa oscilloscope; two-channel arbitrary waveform generator; triple-output power supply (two programmable); four-channel voltmeter; two programmable reference voltages; 32-channel logic analyzer; 32-channel pattern generator; and an assortment of digital I/O devices. Users can complete designs anytime, anywhere.

WaveForms easy to use interfaces allow users to acquire, store, analyze, produce, and reuse analog and digital signals. A high speed USB2 connection ensures all instruments respond in near real time. WaveForms data files are stored using standard formats, making it convenient to share data between instruments or export data to word processors or graphics editors.

New users can quickly familiarize themselves with the board and software with the included starter kit and the "My First Experiment Guide." The guide includes simple step-by-step instructions which show the user how to build and test circuits made with parts from the bundled analog starter kit. As a complement to the EE Board, Digilent has published a free, comprehensive set of educational materials designed for use in

introductory analog electrical circuit classes. The materials — titled *Real Analog* — are presented as a series of modules, each covering approximately one week of instruction in a typical university setting. These modules include video lectures and corresponding written materials including: lecture notes, exercises, a homework assignment, and a lab assignment.

The curriculum examines both theoretical concepts and provides practical applications of these concepts; this approach enhances student enjoyment and interest in the topics presented and improves comprehension of basic concepts. Use of the presented circuit analysis techniques in the context of circuit design is emphasized in the lab assignments.

In addition to the bundled analog starter kit, users can purchase other digital and analog parts kits from Digilent. These include: op-amps; low power dual bipolar op-amps; CMOS dual complementary air plus inverter; CMOS hex inverter; single precision timer; FET transistors; over 100 resistors, 12 capacitors, and more. The EE Board is available for the following prices: Non-academic unit $599; Academic unit $399; and Student unit $299.

For more information, contact:
Digilent
Tel: **509-334-6306**
Web:
www.digilentinc.com

continued on page 59

Is your product innovative, less expensive, more functional, or just plain cool? If you have a new product that you would like us to run in our New Products section, please email a short description (300-500 words) and a photo of your product to:

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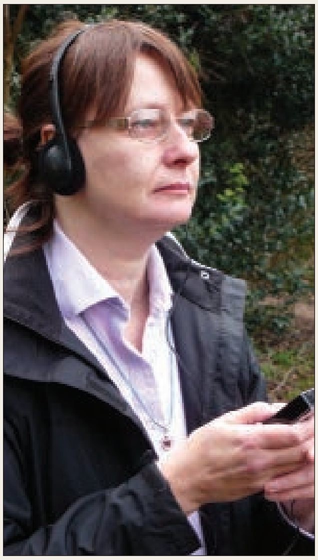
SHOWCASE

BUILD A BAT DETECTOR

By Jonathan Berber



Back in the 18th century, it was suspected that bats navigated using sound, but it took until 1938 to conclusively demonstrate echolocation. The mechanism almost exclusively utilizes ultrasonic frequencies which are inaudible to humans. In brief, bats emit high frequency, short duration energetic pulses of sound and interpret the echoes that return to their ears. The sounds have been shown to be quite complex, featuring swept frequency chirps and constant frequency components. Some people (including me) can hear a limited portion of the sounds emitted by bats. This may be the lowest parts of their frequency modulated content. Certainly, it's perfectly possible to be surrounded by bats alongside some woodland at dusk and hear nothing but their wings fluttering.

Listening In

That's where the bat detector comes in. By down-converting the ultrasound into our audible range, we can indirectly detect it and at least enjoy a window into the hidden world of echolocation. It has been suggested that bats utilize delay times, arrival time differences, and the Doppler effect to interpret echoes. Of course, we can only guess at what bats actually perceive. Perhaps the end result is somewhat analogous to vision, with an image that is refreshed as new information comes in.

This bat detector is a heterodyne design. This means that realistic sounding calls are heard, but bear in mind that they have been frequency shifted and are representative artifacts of the original sounds. Nevertheless, the sounds heard with this detector are highly informative with real scientific value. It is perfectly possible to identify bat species by careful observation using this detector as their call patterns are species-specific and can be quite distinctive. I personally (along with a knowledgeable assistant) have identified two species locally, namely brown long eared bats and common pipistrelle bats.

What is Heterodyne?

The incoming ultrasonic signal is mixed with a locally generated signal that is close to the same principal frequency. The mixer output contains a signal which is the difference between these two. So, for example, if the incoming sound is based at 45 kHz and the local oscillator is running at 42 kHz, the output will be around 3 kHz — nicely within the range of human hearing. Interestingly, the same output would also be produced if the local oscillator was set to 48 kHz as the mixer produces difference signals in both senses, positive and negative.

The block diagram in **Figure 1** is pretty much as it

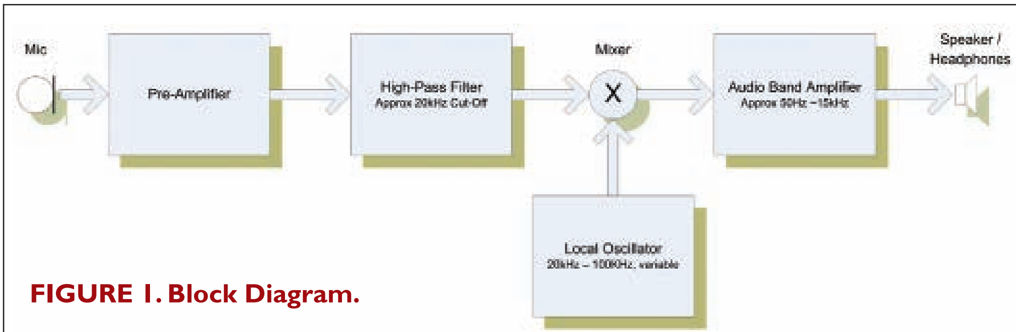


FIGURE 1. Block Diagram.

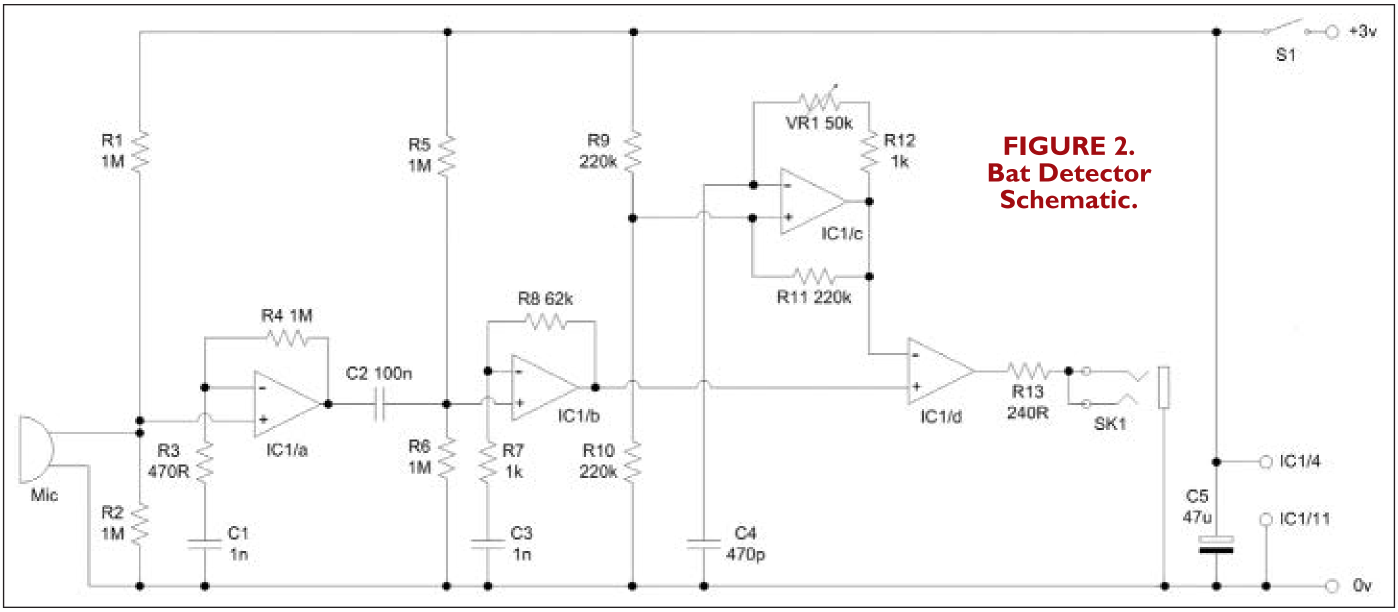


FIGURE 2. Bat Detector Schematic.

was when I first sketched it out. The project subsequently grew from it. The diagram shows the main functional components, starting at the microphone which is sensitive to ultrasonic frequencies. This feeds a pre-amplifier and high pass filter combination. The amplified signal is combined with the local oscillator output in the mixer. The local oscillator is adjusted so that its tone is close to the ultrasonic frequencies of interest. The mixer effectively multiplies the ultrasonic signal with the local oscillator tone and produces audio-band signals representing their difference. The audio band amplifier block buffers the mixer output and drives the user's headphones.

Circuit Description

Unlike competing designs which use quite complex digital processing techniques, this project uses straightforward analog circuitry comprised of a quad op-amp and a handful of passive components. With the possible exception of the microphone, most hobbyists will find that everything needed is already at hand, making this an unusually inexpensive project.

The circuit diagram in **Figure 2** shows the complete project and it really is as simple as it looks. Each of the four amplifiers in the quad op-amp IC is used as a building block, and these correspond quite closely with the functions shown in the block diagram. IC1/a and IC1/b comprise a two-stage, high gain microphone pre-amplifier. Capacitors C1 and C3 were selected to produce a two-pole, high pass filter characteristic which blocks audio-band input while favoring ultrasonic frequencies.

Resistors R3 and R4 were selected for high gain in IC1/a — consistent with acceptably low noise. The gain of IC1/b is set by R7 and R8. The latter was, in fact, selected to match the sensitivity of the microphone, given the high gain of IC1/a. It may be necessary to alter R8, depending on the specific microphone used. For this reason, it is worth considering something like a 220K potentiometer in its place during construction and initial setup.

IC1/c is a conventional RC oscillator. Its frequency is determined by C4 and the combination of VR1 and R12. With the values shown, the usable range is about 15 kHz to 110 kHz.

IC1/d serves as our mixer, combining the filtered and amplified input signal with the local oscillator tone to produce an audio-band signal. IC1/d also buffers the signal and drives the headphones. Resistor R13, in series with the headphones, was found to be necessary to prevent feedback. It's not quite clear whether the feedback arises via the external headphone-microphone route or it is an electronic circuit phenomenon, but it was an unbearable effect which R13 completely cured.

Measured battery drain is just 5 mA when a 3V supply is used as shown. Using a 9V battery instead increases consumption to 20 mA.

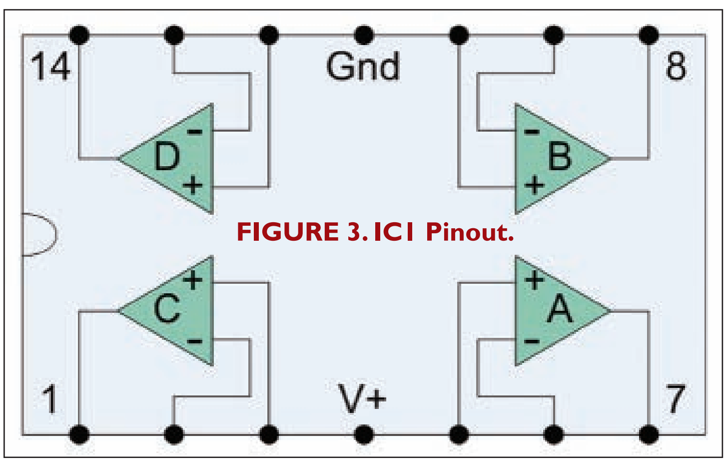
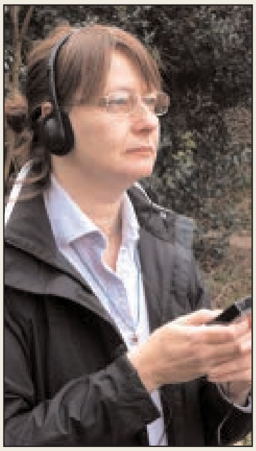


FIGURE 3. IC1 Pinout.

Using The Detector



Expert biologist Dr. Ochre Brittlegill was only too pleased to assist with evaluating the performance of the bat detector. Having surveyed a tract of English woodland several times, Dr. Brittlegill had established that at least two species of bat were present. Making definitive identifications was proving tricky, however. Listening to their distinctive echolocation features such as pulse repetition rate and frequency sweep, our expert identified the smaller species as common Pipistrelle (Pipistrellus pipistrellus), a widespread resident with a wingspan of around 19-25 cm (7.5 to 10 inches). The larger species proved to be the brown long eared bat (Plecotus auritus) which has a wingspan of about 22-25 cm (9 to 10 inches).

Mixed woodland adjoining open spaces such as fields is ideal for many bat species. Ancient trees such as the venerable old oak, shown in the photo, provide myriad roosting opportunities. Bats use ultrasound for social communication, as well as for echolocation. The frequencies utilized for this purpose are generally considerably lower, as indeed is the volume. With a little patience, Dr. Brittlegill was able to tune into the faint chattering in some bat roosts early in the evening before the nightly hunting for food got underway.

Choice of Components

The project was constructed around an LM324 quad op-amp, simply because it was available. Other similar quad packages will most likely work just as well, and the IC pinouts are usually identical but check to be sure first. While we're on the subject of pinouts, note that the four op-amps in ours have been labelled to match the suggested circuit layout, not the conventional order usually seen. (See **Figure 3**.)

The microphone used in this project was in fact a simple piezo sounder, selected for best performance from a variety that were at hand. (More on this later.) The decoupling capacitor C5 is an electrolytic type. For the suggested layout, an axial-leaded component is most convenient, although a radial-lead one could be used. Its value is listed as 47 µ, but it is not at all critical and anything in the range of about 22 µ to 100 µ would be fine.

The passive components (resistors and capacitors) are entirely conventional, as shown in the **Parts List**. It is unlikely to matter whether polyester or ceramic capacitors are used, so just pick out the parts from what you have available. In a similar vein, the project case, battery box, and headphones can be selected according to taste and availability, as well. If desired, you may elect to use AAA cells instead of the larger AA ones. Power switch S1 and frequency control potentiometer VR1 may also be chosen to suit your needs. It is worth bearing in mind that having a numbered scale around VR1 has proved to be indispensable when using the device.

Construction

While it is certainly possible to create a PCB for this project, it's hardly worth all the effort. The circuit can be readily constructed on strip-board such as Vero board, producing a satisfyingly neat, durable, and reliable result.

The suggested layout fits on a 1.25 x 2 inch board. It is 18 holes high and 12 tracks wide, and requires just 14 track cuts. Experienced builders may of course prefer to adjust the layout as desired.

Gather together all the electronic components first, then prepare the board. It may be better to build up the circuit on a large piece of Vero board first and then cut it to size afterwards. This makes it easier to handle the board while soldering. Carefully drill out all the breaks in the copper strips, preferably using a simple hand tool. Insert the components and secure them lightly by bending their wires a little with needle-nose pliers. It can be easier to do a few parts at a time. Watch the polarity on C5 and the orientation of IC1. Solder the components in, then clip off surplus wire neatly. The suggested layout uses five wire links on the component side of the board and four on the solder side to bridge across the copper tracks.

Sharp-eyed builders will notice that R7 and C3 have been swapped over to make the layout a little more convenient. As these two components are simply connected in series, this does not affect circuit behavior in any way.

One lead of the 62K resistor R8 goes right over a wire link without being in contact with it. It may be advisable to slip a short piece of plastic sleeve over the link to ensure that the wires cannot inadvertently come into

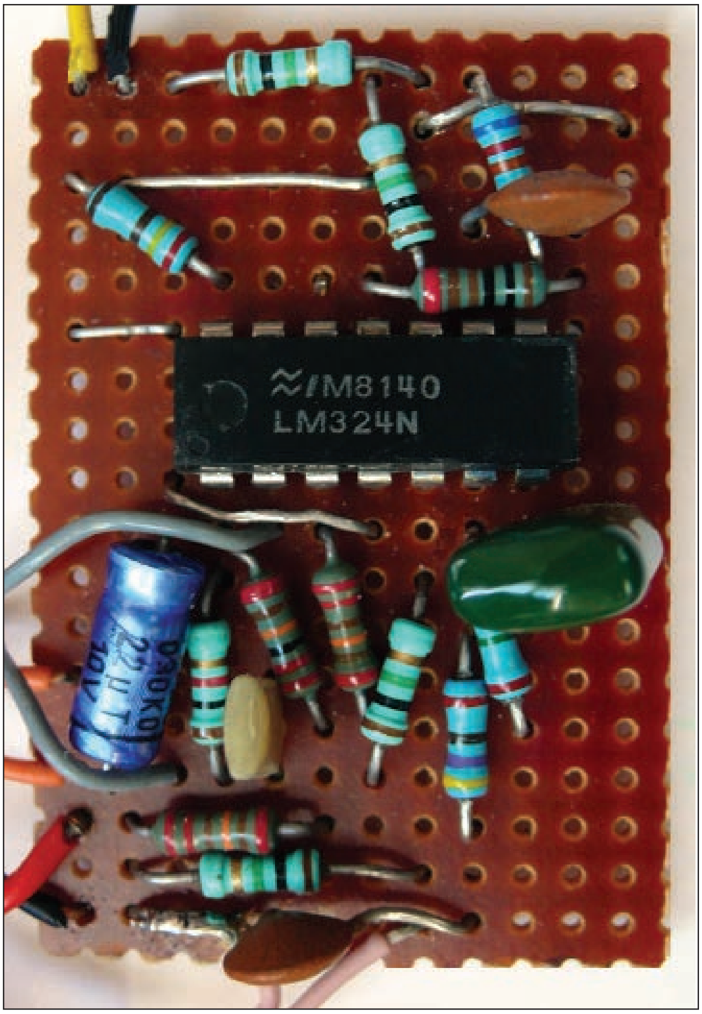


FIGURE 4. Circuit Board (component side).

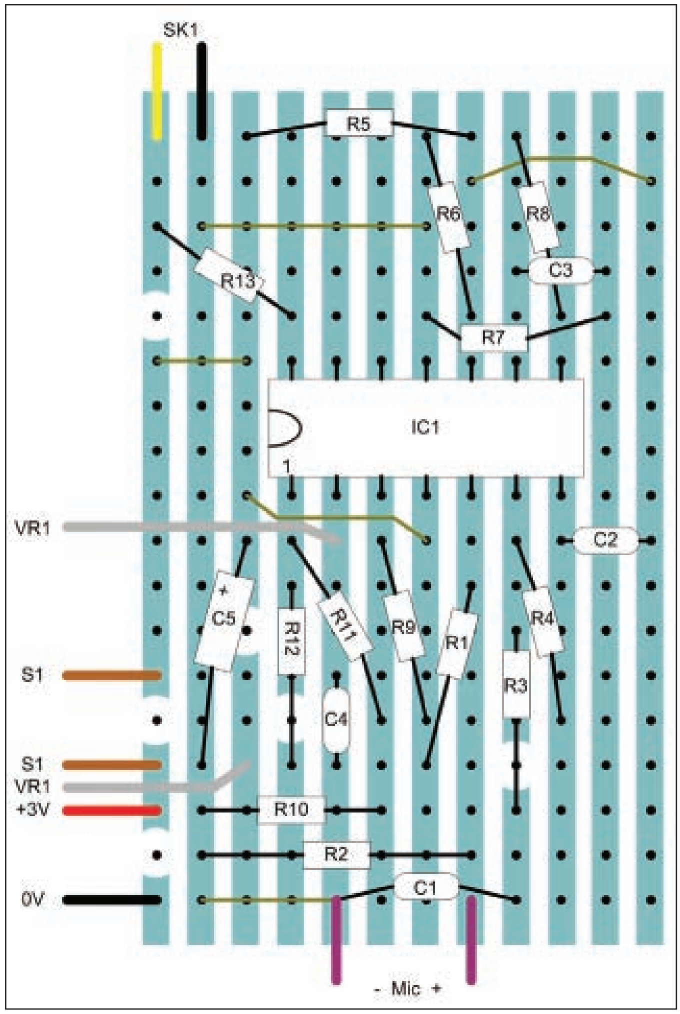


FIGURE 5. Board Layout (component side).

electrical contact.

Once the components are mounted, add the various connecting wires. In the photograph of the circuit board in **Figure 4**, the pink wires go to the microphone and the gray wires go to the potentiometer. Red and black are from the battery box; these are positive and negative, respectively. The orange pair is from the power switch. The Vero board cuts are arranged to place the switch in series with the battery. Finally, the yellow and black wires feed the headphone socket.

Initial Testing

Plug in some headphones, power up the circuit, and take a listen. As the frequency potentiometer is turned, noise should be heard. The intensity and spectral content of the noise varies a great deal across the control range. If an oscilloscope or frequency counter is available, examine the output of the local oscillator IC1/c. The frequency range available should be in the range of about 15 kHz to 110 kHz. If no scope is available, it is possible to hear the local oscillator running. Turn the potentiometer towards its minimum value. A high pitch whistle should be heard.

If the circuit is not behaving as it should, it's always worth checking for simple build errors first. Inspect the rear of the board. Are all the wire links fitted? Are there any unintentional solder bridges or whiskers of wire between tracks? Check that all the track cuts are present and in the right locations, and that every component leg is actually soldered. Turn the board back over and look at the component side. Is each item in the correct holes? Try comparing it with the board photograph and layout diagram. Check that all the connecting leads are in the correct locations.

Once it is established that the local oscillator is running, check out the high gain amplifier comprising IC1/a and IC1/b. This is most readily achieved by examining the output of IC1/b with a scope, but, of course, it may also be done simply by listening to the mixer output using headphones in SK1.

Microphone selection is critical. Some experimenters have reported that the usual ultrasonic transducers are not

FIGURE 6. Mic Line-up.

always the best choice. In fact, a simple piezo or ceramic sounder used as a microphone can produce superior results. During development, a selection of sounders were available, as shown in **Figure 6.** They were all assessed and the winner was the flat one on the right. The component was unbranded and was by no means the only possibility.

In contrast with audio projects, ultrasound ones always pose a special challenge: how to simulate the input signal. Having tried all manner of things, the simplest and most effective ultrasound source was actually one's mouth. Making a hissing noise anything up to a meter (yard) away from the microphone resulted in a lovely rush of noise in the headphones, arising from the surprisingly strong ultrasonic components of the sound. Another technique is to rub two fingers together or slide a fingertip over a sheet of paper held near to the microphone.

PARTS LIST

ITEM	DESCRIPTION
Resistors	All 250 mW 5% axial carbon film.
R1	1M
R2	1M
R3	470R
R4	1M
R5	1M
R6	1M
R7	1K
R8	62K
R9	220K
R10	220K
R11	220K
R12	1K
R13	240R
VR1	50K rotary potentiometer (see text)
Capacitors	All polyester or ceramic except C5.
C1	1 n
C2	100 n
C3	1 n
C4	470 p
C5	47 µF 10V electrolytic
Active Components	
IC1	LM324 quad audio op-amp or similar (see text)
Miscellaneous	
Mic	Piezo type (see text)
SK1	3.5 mm stereo phone socket
S1	SPST switch (see text)
Battery	Two-off AA cells for 3V operation
Battery Box	Double AA box to suit construction
Project Case	Select according to construction needs
Headphones	Dynamic in-ear or on-ear type, 300R approx.

Calibration

It is very useful to be able to set the device to the desired frequencies, and conversely to be able to determine what frequency the device happens to be tuned to. For this reason, it's well worth marking or fitting a numbered scale around the frequency potentiometer and then calibrating the device. For this purpose, an oscilloscope or frequency counter is required. Observe the output of the local oscillator while rotating the control across its entire range, and note what frequency corresponds to each point on the scale.

Using the Bat Detector

Once the detector has been tested as far as it can be on the workbench and the dial has been calibrated, it's time to venture out at dusk. Hearing your first bat is a very satisfying experience. Start by setting the frequency to about 30 kHz. You should hear a uniform hiss in the background. It is sometimes possible to hear leaves rustling ultrasonically in the wind, some seconds before the gusts are even felt. Keep as still as possible. At these frequencies, the microphone is highly directional.

When bats are seen flying close by, point the microphone directly at them. The device is sensitive enough to produce good results from quite a few meters (yards) away. You are listening for a series of click or plop sounds as the bat passes by. Some species actually synchronize the clicks with wing motion, giving the illusion that it is wing beats that are heard when, in fact, it is the echolocation pulses.

It can be rewarding to stand among trees during early dusk, directing the microphone upwards. It is possible to hear the chattering of social calls in bat roosts. Try scanning around the lower part of the frequency range as this is generally used for social communication. Who knows how many bat species you'll be able to identify. **NV**

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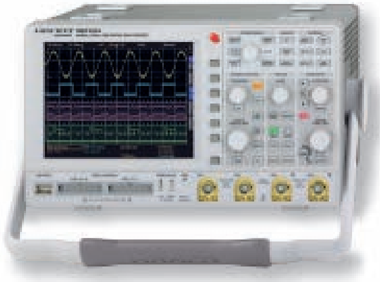

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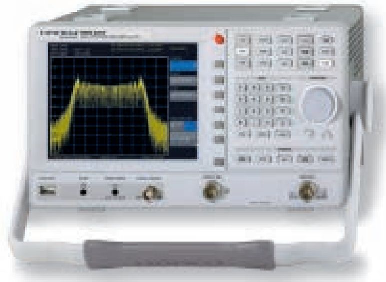

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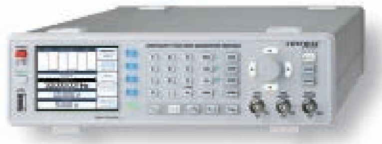

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- Rise time < 8 ns, in pulse mode 8...500 ns variable-edge-time
- Pulse mode: Frequency range 100 μHz...12.5 MHz/25 MHz,
  pulse width 10 ns...999 s, resolution 5 ns
- Modulation modes AM, FM, PM, PWM, FSK (int. and ext.)
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- Internal modulator (sine, square, triangle, sawtooth) 10 Hz...150 kHz/200 kHz
- High spectral purity
- Standard: TCXO (temperature stability: ± 0.5 x 10^{-6})
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- Galvanically isolated USB/RS-232 Interface, optional IEEE-488
- 10 configuration memories including turn-on configuration

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HOW I SCRATCH-BUILT A FIVE FOOT LONG RADIO-CONTROLLED SUBMARINE

Part 2

This is the second part of a three-part account of an extraordinary 10 year engineering project I undertook that succeeded against all odds. My last article explained the planning stages, fabricating of the hull and rudders, the propeller, and the silicon mold preparation for my five foot submarine project. This time, I'll explain and show the actual assembly of the components into the overall body of the sub itself. As I mentioned in Part 1, no matter what type of DIY work you are engaged in, you will find herein some electro-mechanical assembly techniques that will prove helpful.

By Michael Wernecke

Hull Preparation

The hull is ready to have the openings on the top and bottom cut out. **Figures 1** and **2**, respectively, show the flood holes on the bottom and upper hull which were cut out. Sidebar **Figure A** shows the small electric saber saw I used for the holes. This is a 12 volt saw, so I needed to connect it to a 12 volt battery. The saw has two small blades that reciprocate past each other, making a nice cut through the fiber-glass epoxy hull and making the hole cutting easy. **Figure 3** shows the method I used to connect the hatches to the upper hull. This simple three-part system worked well and needed the usual fine sanding and fitting. One small .052" diameter brass rod holds the hatch to the centra (plastic) block, which then attaches to the hull with super glue. You can speed up the drying time of super glue by sprinkling baking soda on it. **Figure 4** shows the finished hatches on the model.

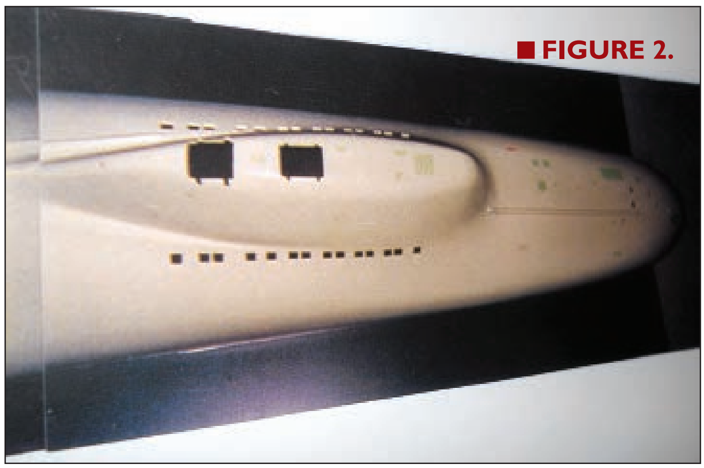
Stern Assembly

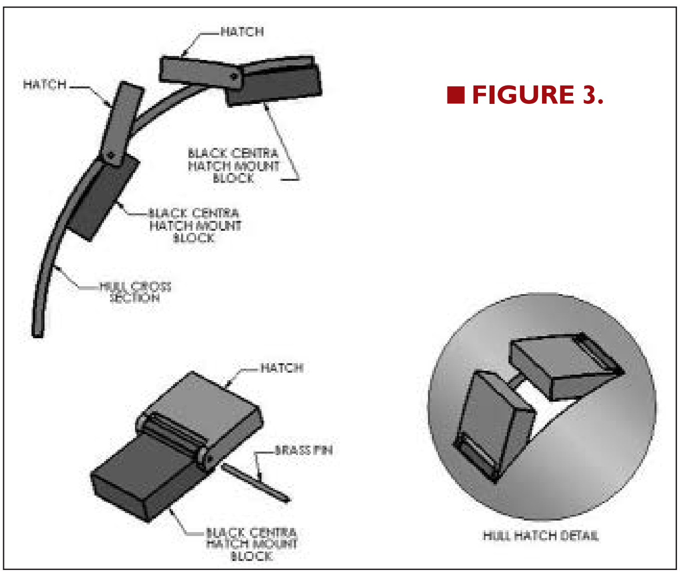
The propeller components in **Figure 5** are the shaft, the stuffing tube, the propeller, and centering block. The propeller shaft stuffing tube will be press-fit into the centering block which will be positioned as shown in the rudder detail in **Figure 12**. The stainless steel stuffing tube is hollow and allows the propeller to pass through it, while the stuffing tube holds the propeller shaft in position. I affixed the propeller to the propeller shaft with 222 Loctite to make sure the propeller won't fall off while in operation. I have lost propellers — fortunately — while close to shore. Also, before the final stern assembly is completed one needs to examine the unique problem this submarine has with its rudder-propeller configuration.

Rudder Yokes

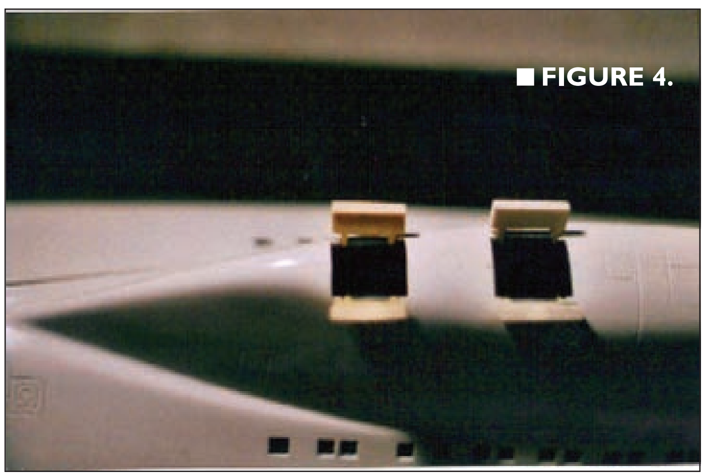
The four rudders on this submarine have to operate in


■ FIGURE 1.

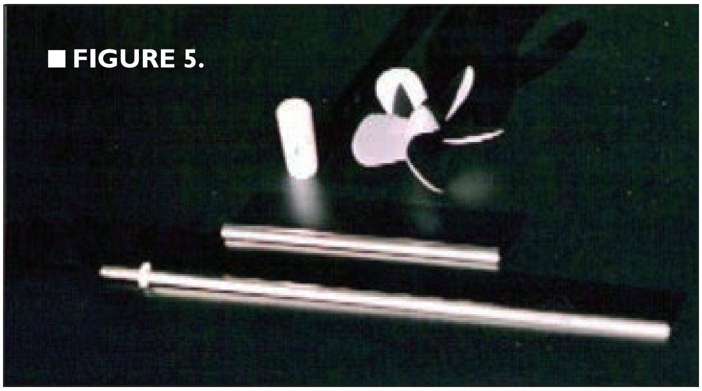

■ FIGURE 2.



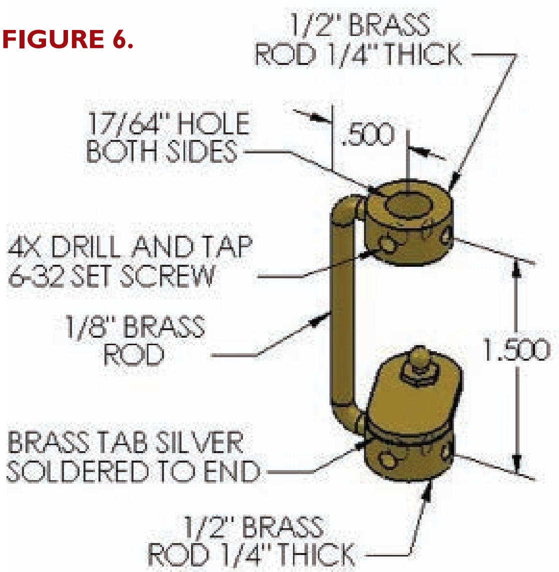
■ FIGURE 3.


■ FIGURE 4.

pairs; the top and bottom ones operate together as one, while the two horizontal rudders operate together as the other pair. There has to be a way for one servo operated pushrod to operate two rudders at a time. My solution is the use of the brass rudder yokes in **Figures 6** and **7**. **Figure 8** shows the final configuration these yokes assume when mounted in the submarine and how the propeller shaft passes through to the propeller. The rudder yokes are made up of four parts. There are four 1/2″ brass rod pieces cut to 1/4″ and drilled at the center for 17/64″. Two pieces of 1/8″ brass rod are then cut to 2-1/2″ and 2-3/4′′ in length, and taped at each end for 6/32″. They are shaped as depicted in the drawings. Next comes some silver soldering fun.



■ FIGURE 5.



■ FIGURE 6.

MAPP Gas

The small brass plates on each yoke assembly need to be silver soldered in place and later have a small ball crank ball positioned on them. Silver soldering is necessary to complete this task. In the soldering realm, you can solder by using increasingly hotter gasses. The lower temperature gas is butane and the hotter gas is propane. For brass and other silver soldering applications, one must use the very effective MAPP gas. MAPP gas kits are available from most hardware retailers.

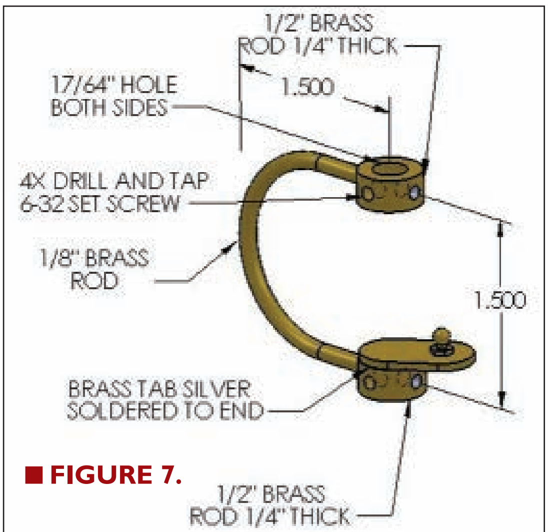
There are a number of tricks in using MAPP gas. MAPP gas comes with two bottles and a small stand to keep the bottles facing slightly upward. You have to keep the bottles in a slightly upward position or the lit gas will steam out in a pencil thin stream and scare the cat. Also, the MAPP gas has another very sinister design.

The gas bottle and the oxygen bottle turn on and off in different directions. When you think you are turning off the oxygen, you are actually turning it on. This tank empties very quickly. Study the MAPP gas procedure carefully before you begin using it. MAPP gas is a great solution to silver soldering.

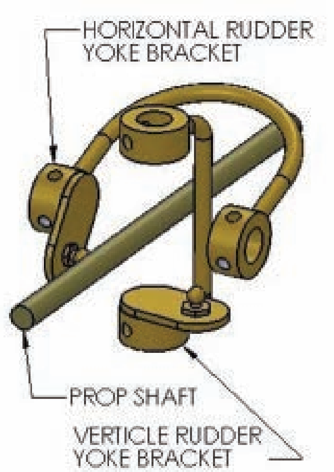
Rudders

Figure 9 shows the holes needed to mount the rudder brackets to the hull. The small holes in the yokes are sized to fit the head of a 1-1/2″ x 6/32″ stainless steel socket head cap screw. The head cap screw will anchor with a set screw into the rudder yokes and turn the rudders. **Figure 10** shows the two horizontal rudders with the 6/32″ socket head screws in position and the rudder yoke in approximate position. When these rudders are mounted, there is movement where the brass rod enters the 1/2″ attachment point and allows for variability in alignment. **Figure 9** also shows the other mounting screw holes. These 1/4″ holes will allow the rudders to be mounted to the hull body and super glued in place.

Figure 11 shows the completed lower horizontal rudders and propeller shaft detail. The other rudder yoke will mount in place with the permanent fixing of the top hull section to the bottom hull. **Figure 12** shows the completed stern assembly which will remain as a separate permanent assembly from the upper hull. The propeller shaft will remain removable



■ FIGURE 7.



■ FIGURE 8.

and will be left out, as it will be easier to connect the rudder bell cranks with the shaft out of the way. Later, the propeller shaft will connect to the motor drive shaft by the aid of a flexible coupling. A flexible coupling is a metal or plastic connecting unit which mounts between two shafts. These two shafts don't exactly match and allow for misalignment where the two shafts meet. See the flexible coupling in sidebar **Figure B**.

Another challenge looms in the next assembly question which is how to connect the top hull section to the bottom hull. I will explain my ingenious solution to this problem in the following paragraphs.

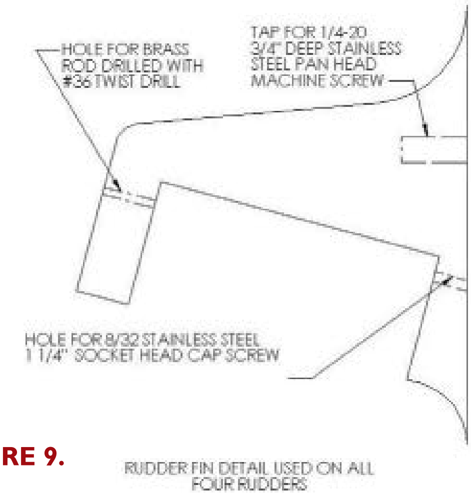
Watertight Cylinder

Figures 14 and **15** show my stern-mounted watertight cylinder. This part of the build was great fun. One item which gave me a great leap in electrical savvy was the purchase of a 12 volt Pittman motor. The motor is the heart of this cylinder. The cylinder has three simple components: two servos and the motor are housed in this watertight chamber. I cast the end-caps and bought the O rings that seal the cylinder. Mike's Subworks sells the shaft seals which allow for the servo pushrods to penetrate the end-cap and keep the cylinder watertight.

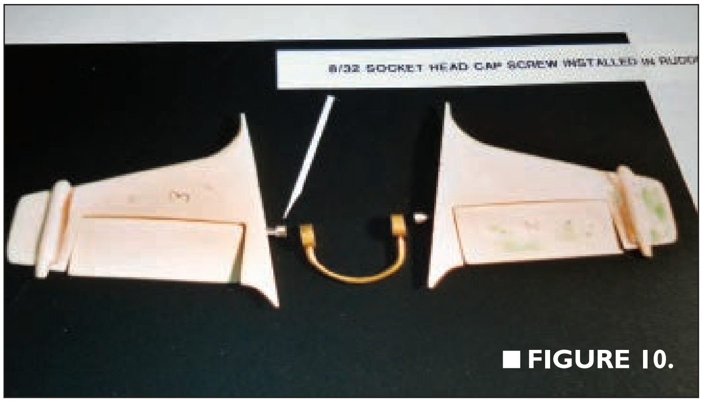
Close observation shows the motor in **Figure 14** to be mounted low in the cylinder to help create a low center of gravity for balance. This wasn't the great idea I had thought it was at that time, because it required me to move the whole cylinder to the front of the boat to allow for the cylinder shaft to match up with the rear shaft as it exited the stern.

Later, I found that I lost space for my electrical box by moving this cylinder forward, since I needed the ballast tank to be in the center of the ship. I wouldn't make it that way again. Preferably, the motor drive shaft should be centered with the propeller shaft exiting the sub.

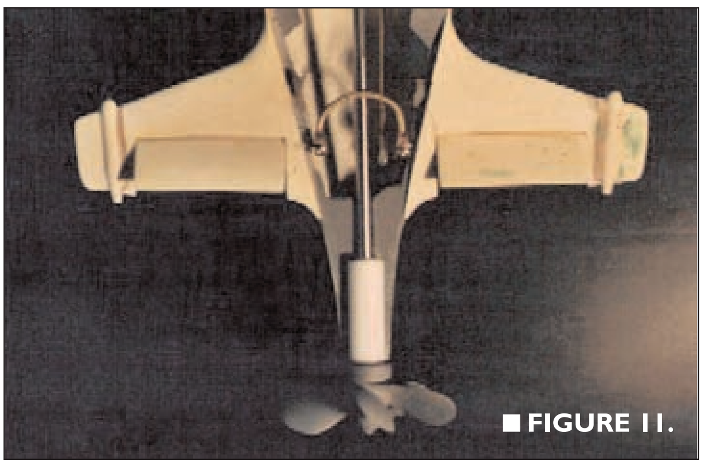
I made a prototype mounting plate out of cardboard to locate the openings for the motor and servos. I later made a second prototype out of plastic, then the final one out of aluminum. To make sure that the servo's sweeping motion wouldn't wear out the shaft seals, I replaced the servo arms with gears and ran the pushrods with a rack and pinion system in order to push the pushrods straight



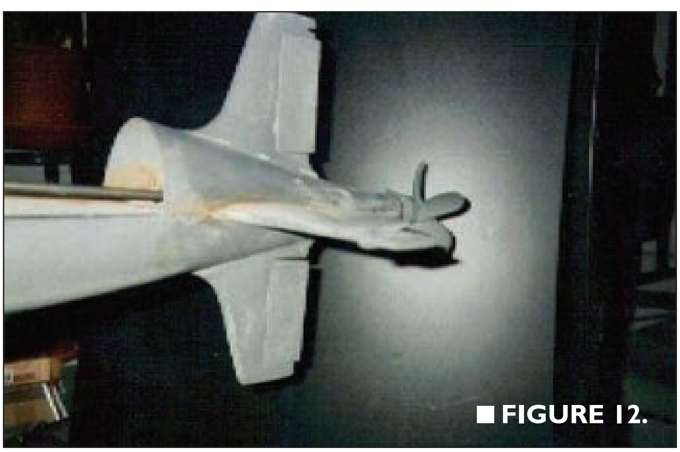
■ **FIGURE 9.**



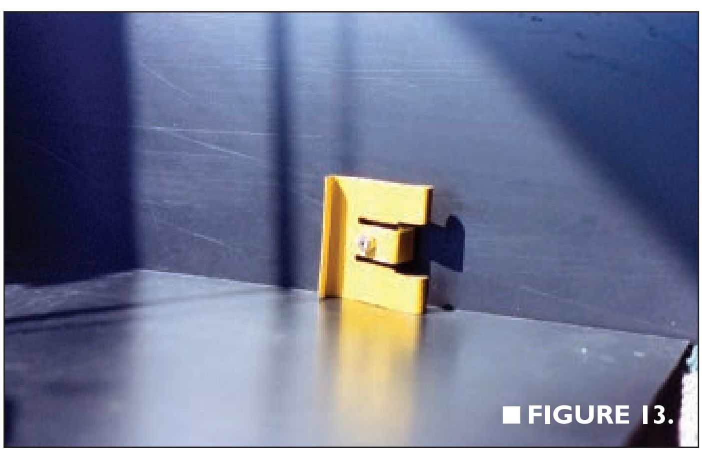
■ **FIGURE 10.**



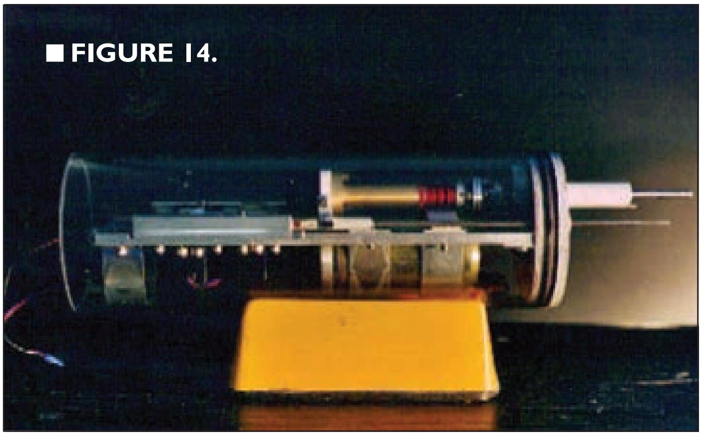
■ **FIGURE 11.**

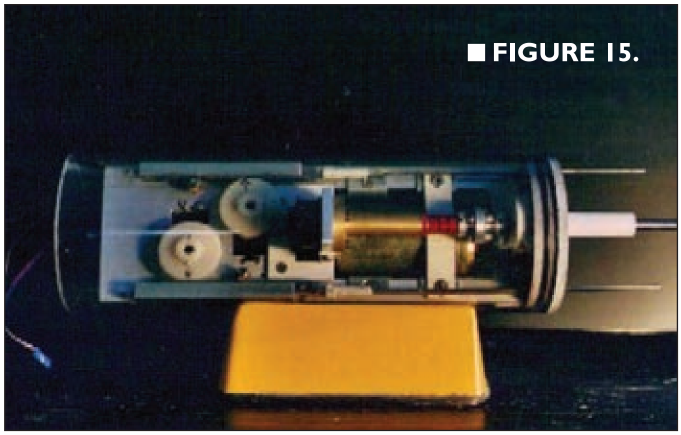


■ **FIGURE 12.**



■ **FIGURE 13.**


■ FIGURE 14.


■ FIGURE 15.

through the rear end-caps. **Figure 15** shows the cylinder top view and the round nylon pinion gears which operate the rack and pushrods. The rack and pinion gears are at the sides and have a small idler gear to keep the racks flat against the channel they are located in.

In lowering the motor in the cylinder, I needed to use a short slotted belt and two gears to transfer power to the short propeller shaft. The motor shaft faces the bow and transfers motion rearward through the end-cap via a short propeller shaft over the top of the motor. This again connects with the always useful flexible coupling. I used another version of the flexible coupling to connect the short shaft inside the cylinder seen in **Figures 14** and **15** to the short shaft outside the cylinder.

The flexible coupling in the cylinder is the item to the right of the red bearing in **Figures 14** and **15**. At the extreme rear of the cylinder is the stuffing tube (in gray) containing grease which seals the cylinder from flooding with water. Grease is a good sealant and is what creates a watertight seal at the propeller shaft.

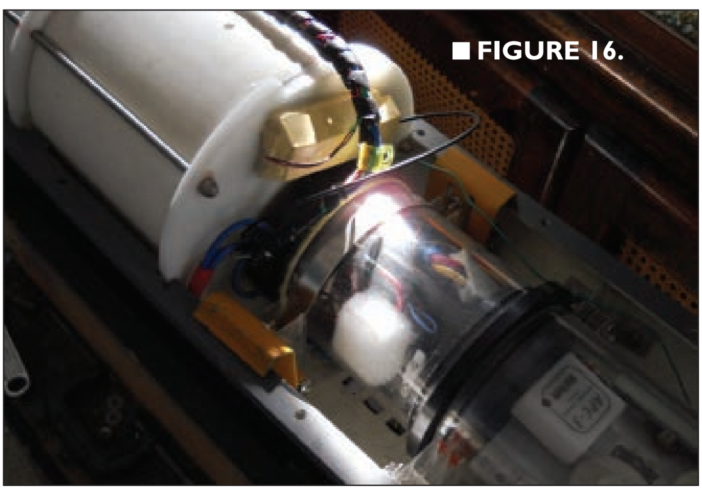
Cylinder Clips

The watertight cylinder is held in the hull using the plastic supports shown in sidebar **Figure C**. Holding the cylinder in place is a stainless steel bracket made from .030" feeler gauge. See the clip page in **Figure 13** to view the ingenious yellow clips which serve two duties.

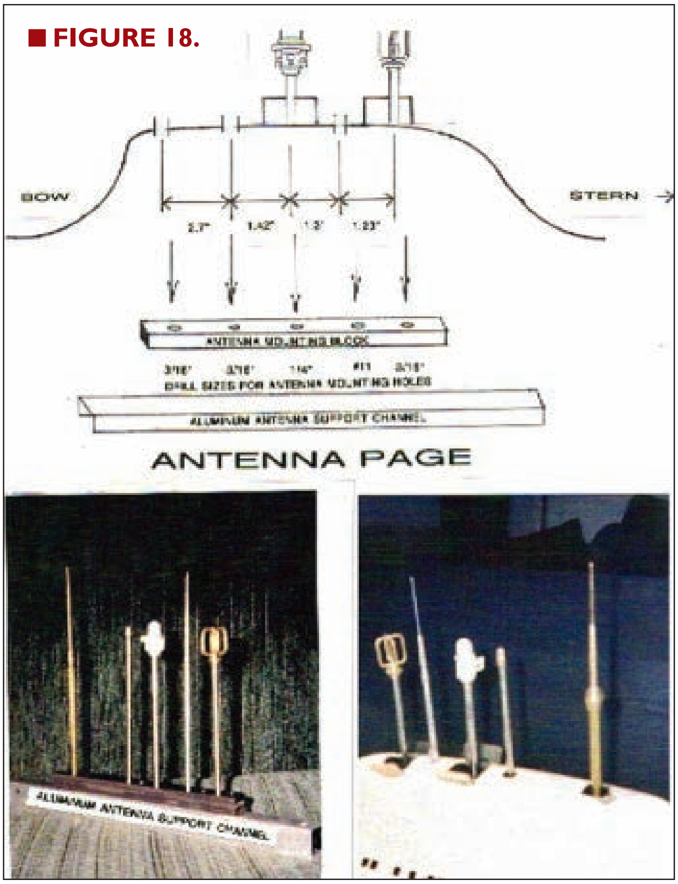
The problem of holding down the top hull to the bottom hull was an issue I deliberated about at length. The hull pin alignment system requires that the upper hull must be lifted straight up from the bottom hull. I also had to hold down the watertight cylinder. Somewhere in the recesses of my mind, the solution to this issue dawned on me. I thought I would use clips at the hull mid-point of the lower hull to hold down the upper hull and use a small hole in the hull side to push the clips open and release the upper hull. The solution was the .030" feeler gauge that was to hold down the watertight cylinder. The outward pressure created by this feeler gauge would act as a spring to push the yellow hull clips outward. The outward pressure can be countered by pushing the clips inward with an Allen wrench inserted through the small holes in the hull which would allow the upper hull to lift off the lower hull. I never planned on this as a solution, but I could tell what the potential was when I saw it. Two small holes below the waterline on either side of the hull would be the sites for my opening locations. See sidebar **Figure D** to view the opening procedure.

The remaining connections are the pushrods at the rear of the watertight cylinder that connect to the rudders. The detail of the connections is shown in **Figure 17**. I glued these plastic rods to the pushrods exiting the watertight cylinder. There are many ways to connect the push-rods to the rudder yokes.

The typical connection from the pushrods to the rudder yokes is via brass rods. I liked the plastic red and yellow rods when I saw them in a model plane hobby


■ FIGURE 16.

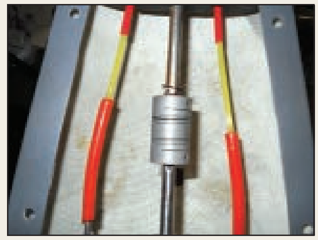

■ FIGURE 17.



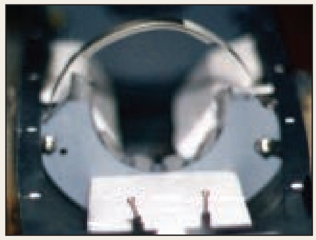
■ **FIGURE 18.**

Tools and Tips

■ **FIGURE A.** Twelve volt reciprocating saw and battery used to cut flood holes.



■ **FIGURE B.** Flexible coupling used to connect the propeller shaft to the motor drive shaft.



■ **FIGURE C.** Watertight cylinder hull supports.

■ **FIGURE D.** "T" handle Allen wrench inserted into hull clip release holes which are used to separate the lower hull from the upper hull.

shop and used them. I like the mixing of materials from one engineering application to another.

Figure 18 shows the antenna array. These units were mostly turned on a small lath and soldered together.

Closing Thoughts

In Part 3, I will explain the twists and turns the electrical system put me through. I will also show you a method whereby you can increase the electrical capacity of your radio transmitter by a thousand percent. Further, I will provide the answer to the question on why my speed control would heat up and stop running. How did I stop the pressure reserve tank from losing air pressure? I will also detail the engineering and designing issues of the air compressor system. Just when I thought I had it all figured out ... **NV**

Special thanks to Carmencita Briones for her outstanding editing work, and to Matt Hall and Pat Green for their help with the graphic images included in this article. Contact the author at ocean_tech04 @yahoo.com.

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USING A GRAPHICS LIBRARY WITH THE 32-BIT MICRO EXPERIMENTER

BY THOMAS KIBALO

In this article, we will extend Experimenter applications with graphics. We are all familiar with character-based LCD displays as they have been around for quite some time, but what if you could have both character as well as graphic displays at the same time? Graphic display technologies are quite pervasive in commercial consumer products. Using graphics enhances the user experience by supplementing standard text with the really cool dynamics of virtual buttons, widgets, and representative bitmap displays.

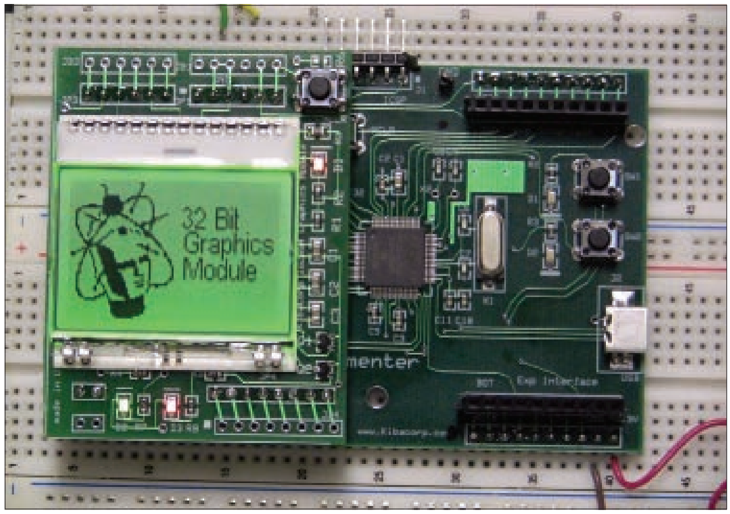


FIGURE 1. The 32-Bit Experimenter and graphics module.

I will show you how comprehensive and easy this technology is using the 32-Bit Micro Experimenter, along with a graphics display and the free Microchip Graphics Library. The Microchip library is very extensive, and provides the basic drawing capability for graphic primitives such as lines, bitmaps, circles, different fonts, and polygraphs, as well as the capability to render graphical objects and widgets like buttons, sliders, meters, and progress bars. In addition, the library provides the ability to dynamically interact with these widgets in real time. This can provide a virtual front panel "look and feel" for all your future user interfaces.

In this article, we will work through a number of experiments to introduce you to all these capabilities. We will also introduce a new hardware graphic module that can be used with the library. Again (as in all articles in this series), a general familiarity with the C language is required.

Microchip Graphics Library Overview

Microchip created their library to cover a broad range of graphical display needs for microcontroller consumer product applications. There are many examples of this in home automation, industrial controls, and medical devices. This library is a series of software based graphical interfaces aligned around functional layers, where each layer contributes to a functional element in the interface. The organization constitutes a high level of modularity where each layer can be adopted or modified for a particular application. This allows users to configure as much of the library as required, without a lot of extensive rework. A block diagram of the library specifically configured for use with the Experimenter and the graphics module is shown **Figure 2**.

The Application Layer is what utilizes the Graphics Library and in itself is not part of the library. The next layer or Graphics Object Layer (GOL) is what renders the widgets, such as button, slider, window, etc. To control these objects, the GOL layer has a message interface

which accepts messages from the Application level hardware.

The next layer is the Graphics Primitive layer. This layer implements primitive drawing functions. These functions execute the rendering of basic graphics objects, such as line, bar, circle, etc. The final layer is the Display Device Driver. It is the only device-dependent layer of the library. This layer talks directly to the based Graphics Display Module.

Because of this modularity, the entire library is portable across different displays and applications. You will see this in the examples in this article. For instance, if only primitive rendering is needed, then applications can interact with that layer directly. If widgets are needed, then the application can interact with the widget layer and this layer, in turn, interacts on the application's behalf to the primitive layer. To interact with widgets, the library provides a strict message structure and rules for message content.

Once a message is correctly populated, the library takes over, and it renders the widget's new status visually. The library initiates a "call back" that allows the user to react to the designated widget change with a corresponding change in the hardware status. You'll see more of this in our widget experiment coming up.

The library provides functional elements that are easily understandable from everyday experiences with similar elements using a PC. The list for all primitives and widgets is shown in **Table 1**. Not all of these widgets will work in a "pushbutton" only environment, and are intended for use with a touchscreen. Also, all of these widgets are rendered to default in full color and are made to appear as a 3-D object on your graphics screen. These default rendering schemes need to be adjusted for a monochrome display (where only black and white are used). The experiments we'll do here deal with buttons and sliders that have been rendered properly in the provided source code.

To use the free library, you'll need to access and download it from Microchip's website. Microchip bundled all of their application libraries together in a collection known as MAL (Microchip Applications Library). To access and download MAL, go to **www.microchip.com/stellent/idcplg?IdcService=SS_GET_PAGE&nodeId=2680&dDocName=en547784**.

The MAL automatically installs on your C drive with the title "Microchip Solutions," along with the date of the MAL as a folder name.

For assistance on any element within the graphics library portion of MAL, navigate to C:\Microchip Solutions\Microchip\Help. While in Help, click the graphics library Help icon. You should see the following application on your computer screen that's in **Figure 3**. This application provides all the information you will require, plus some examples.

The graphics library information is organized as a tree structure in the left side window. Double-clicking on any element of this tree will take you to required information on that element. As mentioned, the library is extensive and I found this Help application invaluable in working through the examples. Another good source of help are the Microchip application notes and tutorials.

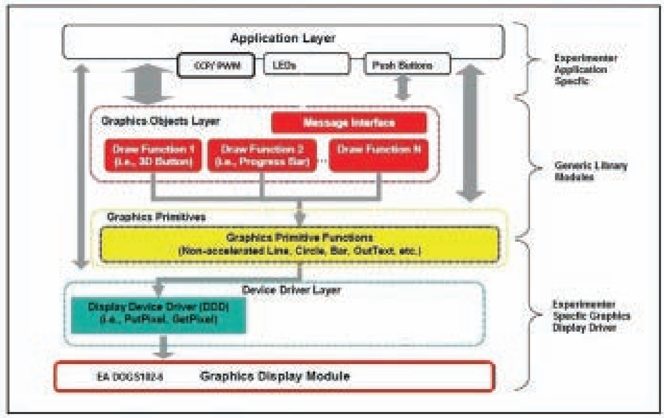


FIGURE 2. Microchip graphics library as used by the Experimenter.

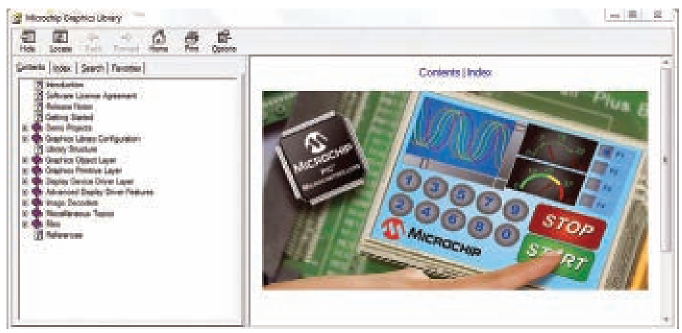


FIGURE 3. Microchip graphics library Help.

The Graphics Module Kit

The graphics display module is based on the EA (ELECTRONIC ASSEMBLY) DOGS Graphics series display technology. The specific display uses a pixel matrix of 102 horizontal by 64 vertical, for a total graphic complement of 6,528 pixels. This is sufficient to handle the Microchip graphics library.

Table 1.

Primitives	Widgets
Text	Button
Line	Slider
Circle	Window
Rectangle	Check Box
Cursor	Radio Button
Bitmap	Edit Box
Polygon	List Box
Point	Group Box
	Horizontal/Vertical Scroll Bars
	Progress Bar
	Static Text
	Picture
	Dial
	Meter

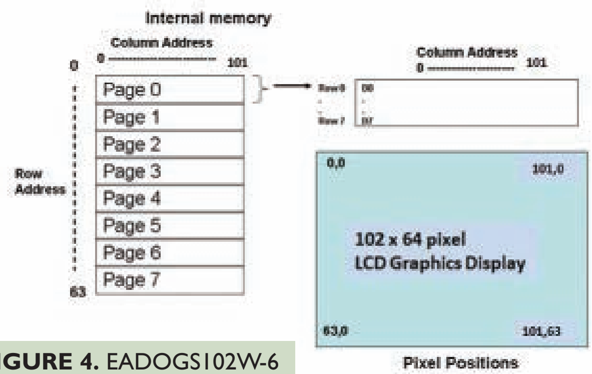


FIGURE 4. EADOGS102W-6 internal display memory and pixel placement.

FIGURE 6. Graphics module kit.

The display is designed for commercial handheld devices, and it is extremely compact with a large viewing area. As a +3.3 VDC module, it's a good display system for use with the 32-bit Experimenter. Also, its compact size and form factor make it easy to mount onto the Experimenter with a plug-in daughterboard PCB. The display is EA DOGS102W-6 and it's used with an EA LED39X41-GR selectable green/red backlight.

The EA LCD display and EA backlight module are assembled as a single unit. The EA DOGS102W-6 display plugs in and sits on top of the EA LED39X41-GR back light. Both parts are soldered together as a complete display assembly.

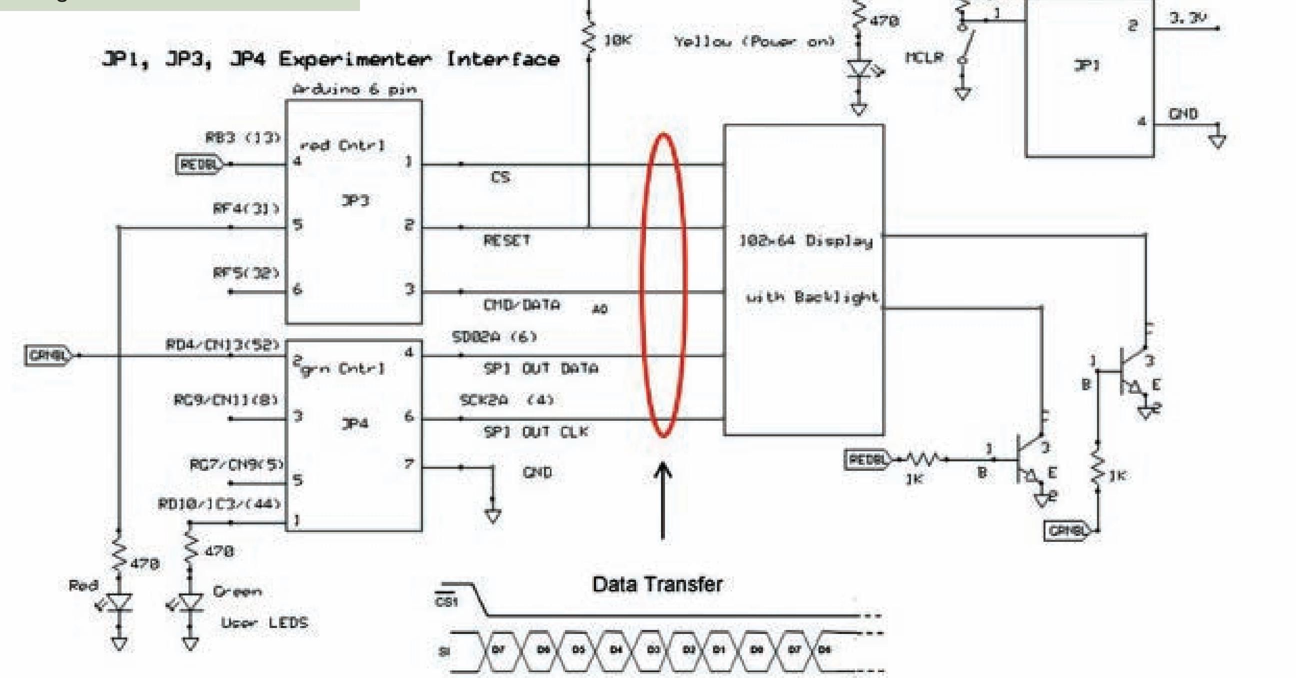
The graphic module board itself contains SMT components that are pre-assembled. The module itself comes as a kit. The only assembly requirement is to solder the display and backlight to the board and headers. The board interface meets Arduino specifications and so can be used with those specific microcontroller board sets. However, the Microchip library is configured to work only with the PIC32. As a final note, the graphics module can be used on a solderless breadboard. This feature makes it backward compatible to the 16-bit Experimenter. (The kit is available from *Nuts & Volts*.)

Hardware And Interfaces

The EA DOGS102W-6 internal memory is organized as eight pages of 102 bytes each for a total of 816 bytes or 6,528 bits. Each bit in the row corresponds to a unique column or X horizontal display pixel position. As described earlier, there are 64 rows, so selecting a row corresponds to a unique vertical Y position of the pixel on the display. **Figure 4** is marked with the individual pixel addresses (X, Y) representing the four corners of the display of the pixel reference map. Setting or resetting a bit for a particular pixel will turn it on or off during display.

Control and writing to the display is handled through

FIGURE 5. Graphics module internal block diagram and SPI.



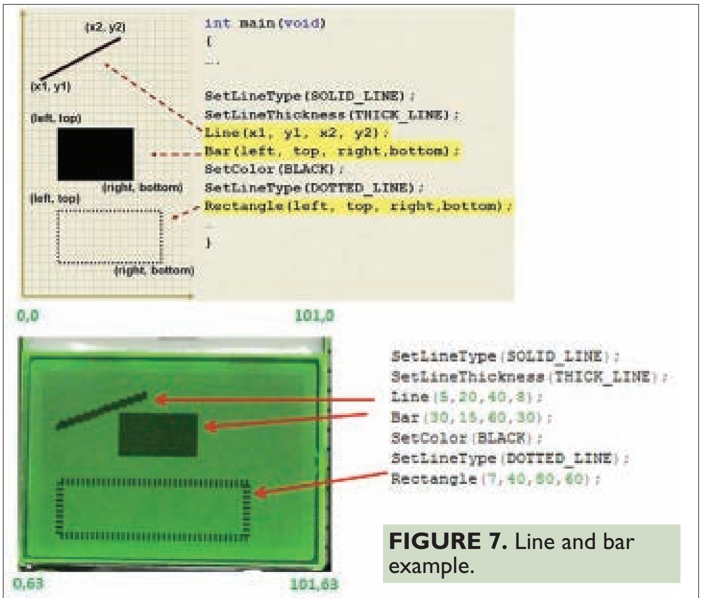


FIGURE 7. Line and bar example.

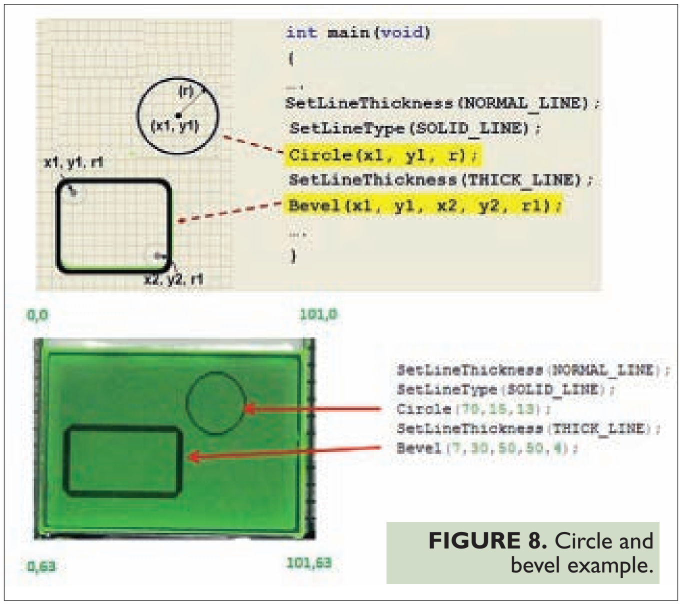


FIGURE 8. Circle and bevel example.

a Synchronous Peripheral Interface (SPI). The use of SPI really simplifies interconnection between the Experimenter and the display. There are only a few controls, plus power and ground: CD for command/data; CS for chip select; /RST for reset; SPI command/data into the display; and SCK for the transfer clock. A timing diagram for SPI is shown in **Figure 5**. The SPI data is clocked eight bits at a time. All communication between the Experimenter to the display is one way; only the Experimenter talks. The initialization of this LCD and the ability to write a pixel to this display are fully integrated in the device driver that is supplied with the demo. The complete system is Microchip graphics library compliant.

Drawing Primitives

The Microchip graphics library supports text, lines, rectangles, and bitmaps as a series of straightforward functions in C. Some mini snippets of primitives are included in PRIMITIVES.MCP (in the article downloads) to illustrate their operation. The first snippet sets line thickness, line type, color (which in our case is only black or white), line, and bar draw. The second snippet draws a rectangle and a circle. The X (values 0-101) and Y (values 0-63) parameters are, of course, the address of pixels on the display. The interface and then the actual code are highlighted and shown in **Figure 7** and **Figure 8**, along with the display results on the graphics module.

Adding Bitmaps And Fonts

Microchip support provides a very cool utility called the Graphics Resource Converter for converting bitmaps (BMP extension) and fonts for use with their library. The utility and associated Help files are located in the C:\Microchip Solutions\Microchip\Graphics\Utilities.

A picture of the resource converter and its associated Help files are shown in **Figure 9**. Be aware that fonts may be copyrighted material, so if you decide to use these fonts with your product, please ensure that you have the rights to do so.

Let's use the Graphics Resource Converter to use with a bitmap. **Figures 10, 11** and **12** illustrate how to select and convert a bit image into a C code array that the library can use to display for an application.

Make sure CLOWN1.C is included as part of the project files set. Set up an external reference to the bit image in the main code. Once this is done, you can simply output to display at any time using the C library "PutImage ()" function. The final code example within Main is shown in **Figure 11**, along with CLOWN1 displayed with text on the graphics module.

Here's an example to show how to do a similar

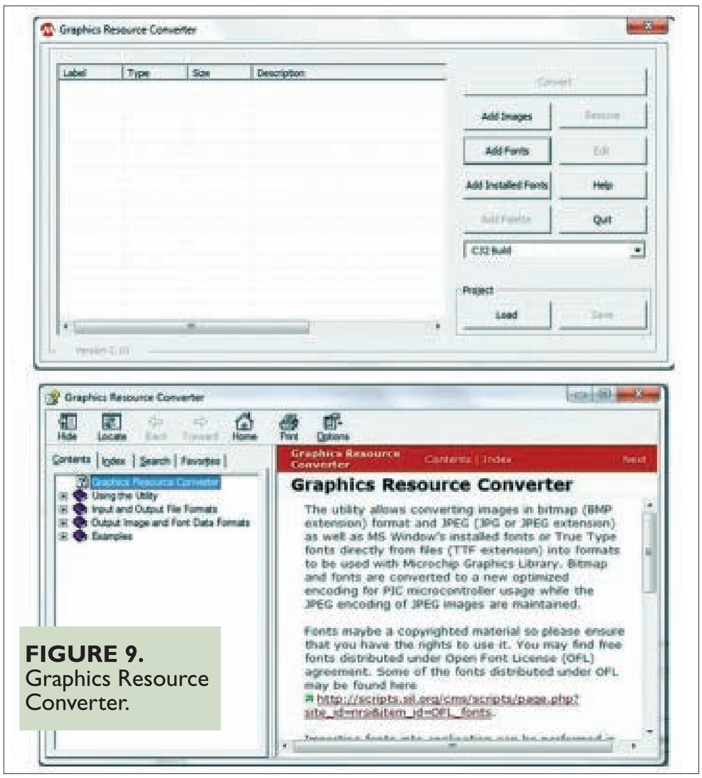


FIGURE 9. Graphics Resource Converter.

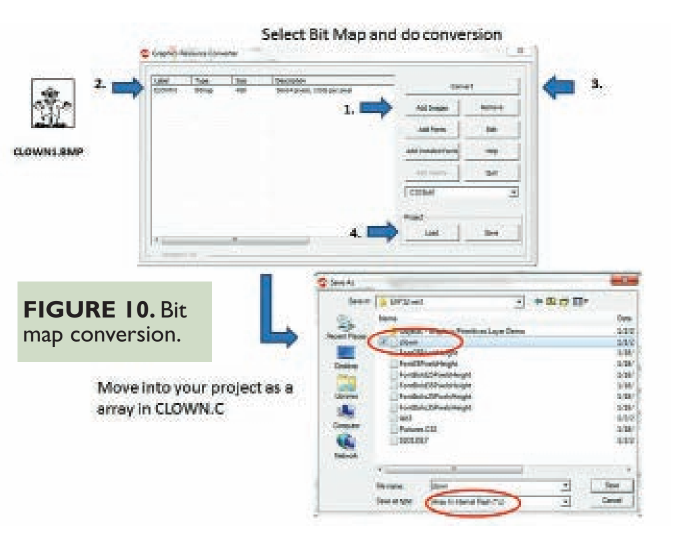


FIGURE 10. Bit map conversion.

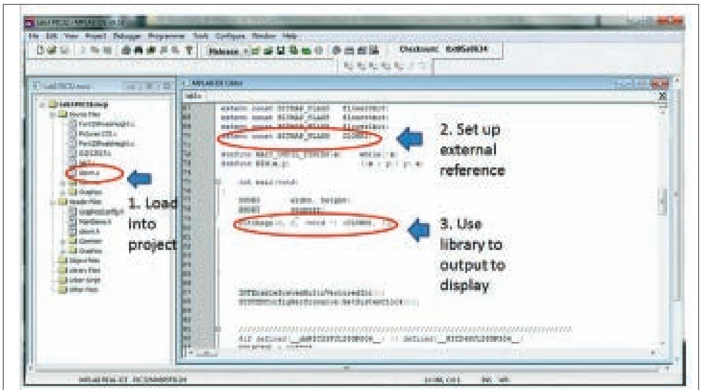


FIGURE 11. Bit map integration.

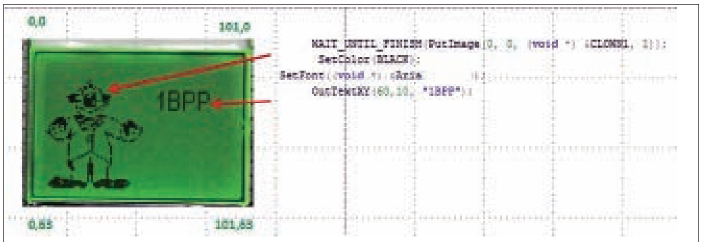


FIGURE 12. Bit map operation.

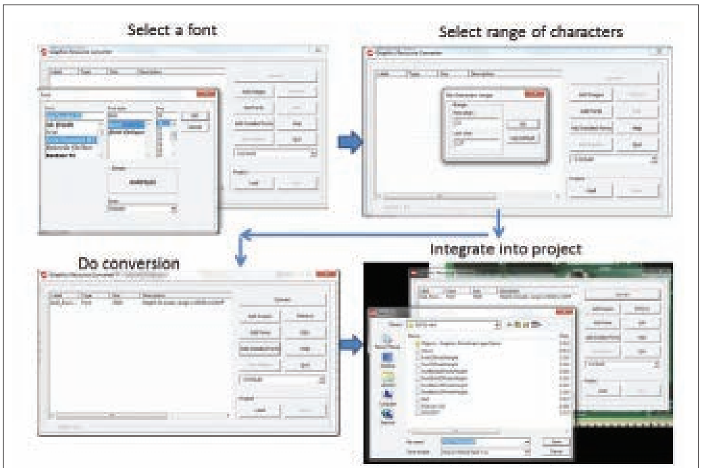


FIGURE 13. Font integration.

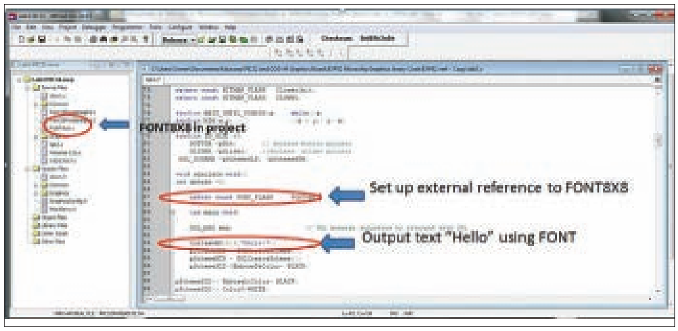


FIGURE 14. Font integrated into project.

function for FONT.

The first step is to select an installed font. Once you select a font, you must then select the range of characters. Once this is done, you then convert the font and add it to the project as a C program array. Now, you have the font integrated into the program and have set up a C code external reference. Select "function calls" to use it with the graphic library (see **Figure 12**). As a final step, the actual code and display results as executed are shown in **Figure 15**. In this example, the font changes among three different types that were installed through the Resource Converter Utility and the display results are shown in **Figure 15**.

Primitives Demo

Some of the highlights of the primitive demo are shown in **Figure 16**. There is significant capability at this level of the library, and I've tried to capture that here. It would be helpful to review the provided source code within the main function of the demo.

As shown, the demo executes an outline of the display, crosses many lines at the center, circles those cross points, fills in those circles, and then does a multi-level rectangular display. Finally, a font and bitmap are completed, and the backlight is configured from green to red. This example is provided as the project Primitives.MCP in the downloads.

Using Widgets

Let's move to the top of the graphics library stack and use widgets. Widgets are those sophisticated graphic objects that are basically comprised of groups of individual primitives, bundled collectively to emulate a well assigned behavior. Specific behaviors are widget-dependent. For example, with the button widget the behavior is push and release; with the slider widget, the behavior is slide forward and backward. To appear as a true button or slider, the widget must also have an accurate graphic representation. The default representations or schemes are full color and truly look 3D. For example, you can visibly see the button on your screen in a press condition or not. These representations have been modified to work in our monochrome environment.

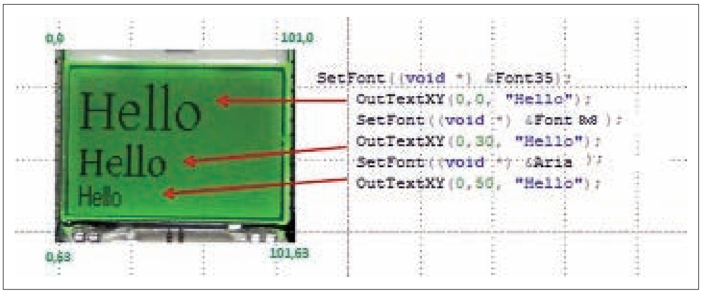


FIGURE 15. Font execution.

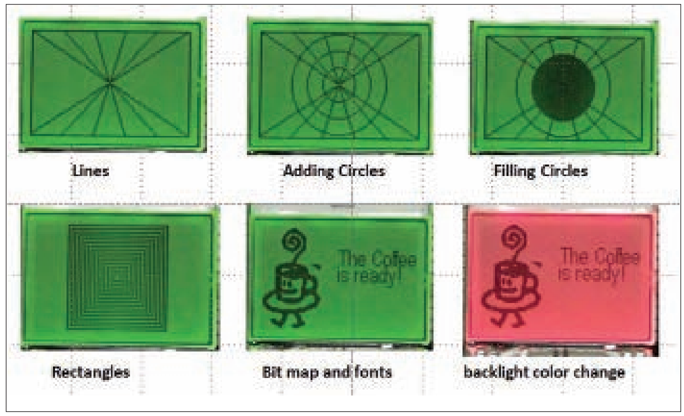


FIGURE 16. Highlights of the primitive demo.

Keep in mind as you attempt to integrate other widgets into your application that a scheme change may be necessary. **Figure 15** shows the widget example we will be working with.

Each of the Experimenter buttons (SW1 and SW2) is assigned a corresponding widget button. As either SW1 or SW2 is pressed or released, each action is mirrored in the widget display representation for these buttons. In this instance, SW2 is pressed while SW1 is not. The auxiliary effect of pushing SW1 or SW2 is to move the slider (shown) left or right incrementally on each depression. SW1 moves the slider to the right, while SW2 moves the slider to the left.

Pretty cool, huh? But it's not really meaningful unless the user truly associates physical action with the widget change. In our example, SW1 and SW2 will show activation on the display corresponding to Button 1 and Button 2. In addition, the slider will move back and forth and maintain a persistent setting based upon SW1 and SW2 depressions. This feature is part of the widget slider behavior that includes min/max and incremental settings.

To make things really interesting, I have tied a pulse width modulation (PWM) output from the Output Compare Peripheral JP4 pin 2 to a 1K resistor in series with an LED to ground. As the slider moves back and forth, the PWM duty cycle changes to dim control the LED (see **Figure 17**). It turns out this same control is used to dim the green backlight. As the LED dims, you should see the green backlight dim as well. The red backlight has no dimming capability — just on or off.

To physically register the button and slider activities in our example, we link activity with the Experimenter Led1 or Led2, and PWM from OC5. Led1 and Led2 will remain

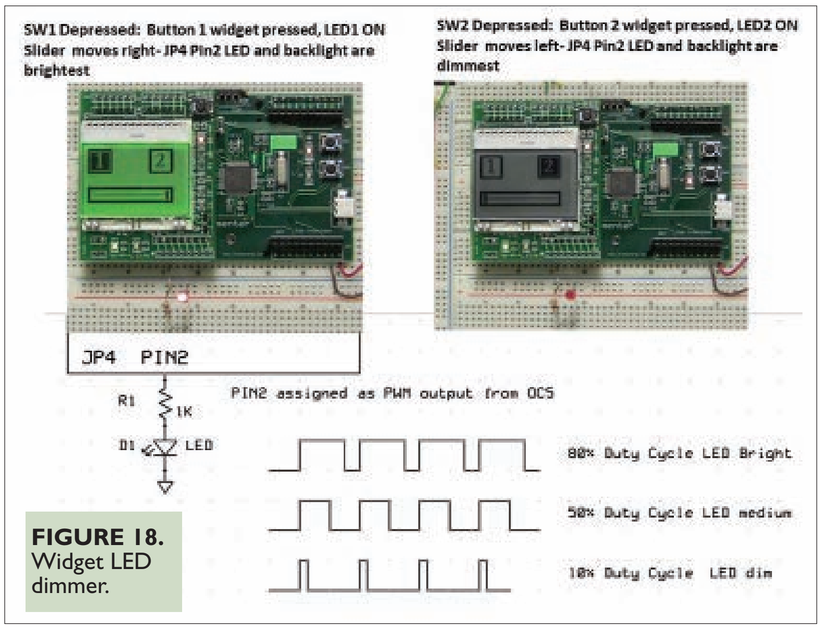
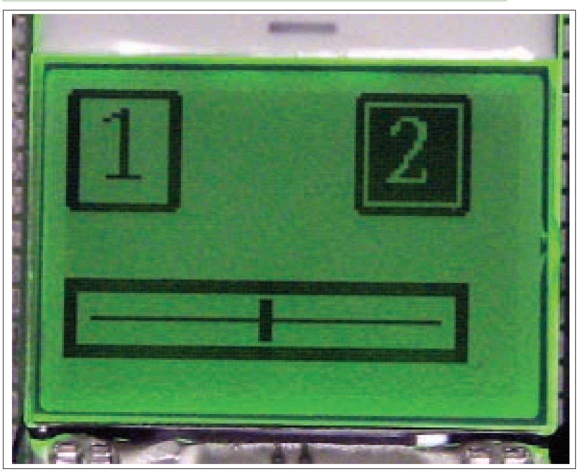


FIGURE 18. Widget LED dimmer.

FIGURE 17. Widget example of two buttons and a slider.



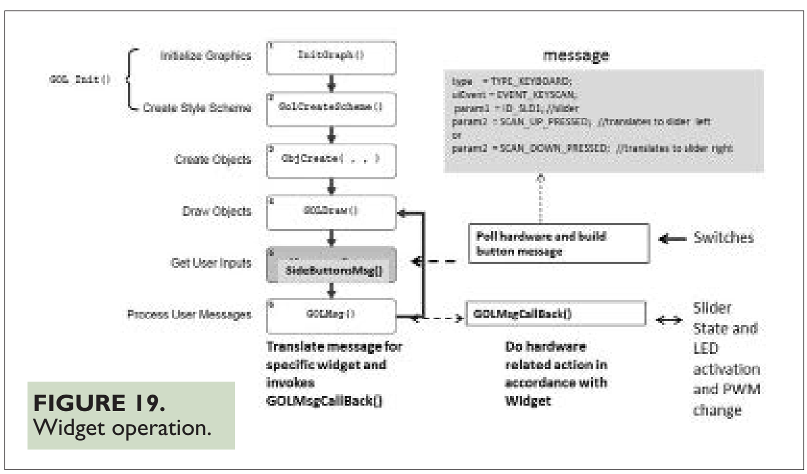


FIGURE 19. Widget operation.

lit through GOLMessageCallBack () based upon their latest pushbutton activity.

We will explore these specific behaviors in more detail in our example project WIDGET.MCP.

Interacting With Widgets

Widgets need greater care and handling than primitives. To use them, you need a collection of supporting functions that are integrated as a continuous loop in your main function. This loop will respond to hardware changes and service the widgets display. The library supports functions to initialize the library, change schemes, and build objects as shown in **Figure 17**.

Widgets have a persistent state based upon what happened previously (i.e., press, release). Each state needs to be captured and displayed. The library function GOLDraw () (graphics object draw) works as part of a continuous loop to do this. On state changes, it will display the new widget image. Also, as part of the loop, hardware is tested for a state change. This state change is captured in a message that is first built under SideButtonsMsg () by polling buttons SW1 and SW2, and is then checked by GOLMsg (). This function translates the message and determines which widget is affected, and then invokes GOLMsgCallBack (). This last function allows the system to invoke the proper hardware changes based upon the widget changed state for feedback and system operation. I encourage you to investigate example code and the library Help for more details.

Where To Go From Here

We have covered a good bit of ground on the Microchip graphics library. Primitive applications are no sweat; however, widgets are more challenging. In each case, you've got some software examples to work with and discover capabilities yourself. We also covered some Microchip utilities that can assist you along the way. We introduced a new graphics hardware module that is fully integrated with the library. (This module will be available in kit form through *Nuts & Volts*.)

I hope that now you are familiar with these advanced graphics techniques, and start to experiment with them, to be able to add these really cool capabilities to your future applications. Until next time, happy 32-bit processing! **NV**

A complete kit to go with this article can be purchased online from the *Nuts & Volts* Webstore at www.nutsvolts.com or call our order desk at 800-783-4624.

#35 SMILEY'S WORKSHOP

C PROGRAMMING - HARDWARE - PROJECTS

Follow along with this series! Joe's book & kits are available at www.nutsvolts.com

by Joe Pardue

avrtoolbox — Designing an Elementary Library: Serial Communications

Recap

Let's get back on track with avrtoolbox [**http://code.google.com/p/avrtoolbox**] after our two month detour to learn about the FT232R USB to serial converter and the revision to my book, *Virtual Serial Port Cookbook*. If you want to get with the avrtoolbox flow, you can find the first three articles in the January, February, and March '11 issues of *Nuts & Volts*. In these articles, we see how to create an open source project, manage software versions with SVN, document with doxygen, adopt a C coding standard, put functions in libraries, and keep things organized.

Introduction

This month, we will learn two more principles for good software project development: the concept of the **Functional Requirements Specification (FRS)** and the **Applications Programmer Interface (API)** — both of which are documents that you should create before writing the code. We will learn about these in the context of creating a serial library that will simplify communications between our AVR and a terminal program on a PC.

This library will provide us with the sorts of easy to use functions we might expect from the Arduino or PBASIC, but with no barrier to moving to real C if we so choose. Our serial library, will sort of mimic the better features of the Arduino serial library while providing much more capable serial output — all the while using regular C for use with the standard Atmel tools AVRStudio/WinAVR/avrdude (not the Arduino IDE).

In case you are snorting at my claim of 'much more capable', let's just say that what I'm doing is encapsulating the venerable C standard library function printf() in a package that makes it easy to use with the AVR without having to read the dozens of relevant pages in the avrlibc manual or the USART section of your AVR datasheet. So, I won't even bother with IMHO for my 'much more capable' assertion.

To help prevent confusion, let me repeat: This article covers three separate topics; two are general software development principles — the FRS and the API — while the third is an application of all the avrtoolbox principles discussed so far, to create a very useful library of serial functions.

Draw the Blueprints Before Sawing the Wood

So, if you were going to build a house would the first thing you do be to go out and buy a bunch of 2x4s and start cutting them up? You'd be surprised at the number of folks who think you can approach writing a program by grabbing a case of Twinkies and Red Bull, and just jumping in and starting writing code. Some people are even proud of this approach. If I'm honest, I have to admit that was the way I programmed when I first started out. I knew exactly what I wanted and so I just jumped right in and did it. However, over time reality taught me that this was not just a bad idea; it was a **very bad** idea.

I found that I'd get well into something only to discover that I'd neglected to plan for one little thing that generally exploded into one big thing. I'd beat that down and hack away until the next little thing I'd neglected to plan for started intruding. It was a vicious cycle of my arrogance getting pounded into submission by the real world. I eventually learned that I should spend time — a lot of time — thinking about a project before allowing myself to write a line of code.

I discovered the hard way that the standard software engineering concept of writing a 'functional requirements specification' before writing any code was not a dumb-bureaucratic-stick-in-the-mud-buzz-kill, but a tool that could help prevent me from committing massive stupidity on a keyboard. It helps reduce the 'massive' part even though

the 'stupidity' part is inherent in programming. As a general rule, I can say that the larger the project, the greater the value of time spent planning. An FRS states what the functions will do, without stating how the functions will do it. Separating the requirement from the implementation keeps the process focused on what needs to be done. Conceptually, this separates the people who want to use the code from the folks who write it. The users group may or may not know anything about creating software, but they know what they want an application they will be using to do, while the programmer may have no use whatsoever for the program but knows how to make it do what the user wants.

I'll share a personal anecdote about a time I helped nearly bankrupt a company that refused to do an FRS up front. I was presented with a program that the client said almost worked and was asked to finish it. The underlying code was a 600 page nightmare that I used as the initial requirements specification, pulling out what the code was supposed to do and tossing the original code in favor of using a bit more modern language that let me re-write it in 60 pages. The boss said, "Great, now I want you to add this one little thing." I choked a bit thinking that if I'd known about that 'one little thing' when I got started, I would have designed the code differently, but I guessed I could shoe-horn it in without breaking anything — which I did.

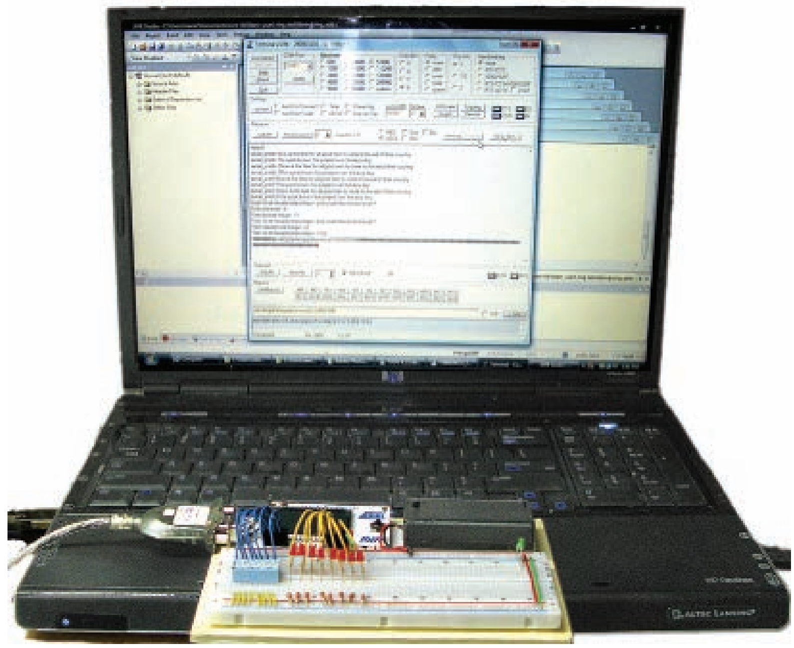
The boss said, "Great, now I want you to add this one little thing." At which point, I delivered him a strident lecture about software engineering principles and insisted that we get it all decided now. He just grinned and said, "Now how difficult can it be to add blah blah?" So, I bent the design further out of shape and added his new requirement and got it all working. The boss said, "Great, now I want you to add this one little thing." Okay, you are probably getting the picture here. We kept going around this circle, the code getting more and more fragile as I kept bending and patching the base trying to fit in each new requirement. So back on topic: **Don't write a line of code until you have the <u>final</u> requirements specified**. Now that I've got that out of my system, let's write that FRS for the serial library.

Serial Library Functional Requirements Specification

The serial library is part of the avrtoolbox elementary libraries and is intended for use by novices. The source code will be written in the C programming language using AVRStudio, WinAVR, and avrlibc. The novice will use this library based on the API document. More advanced users may want to consult the source code.

Some of the requirements for these functions (especially the serial_out() function) are somewhat dense without reference to coded examples, so I recommend that the casual reader may want to refer to the API and the examples to understand what is being specified.

■ FIGURE 1. Serial communication with the AVR Butterfly.



Serial initialization function: serial_begin() will let the user initialize the underlying hardware and software needed to open serial communications with an external UART. This function will allow the user to set the baudrate, but all other UART parameters will be set to the common defaults.

Serial termination function: serial_end() will let the user set the underlying hardware parameters back to the system default values.

Serial input available function: serial_available() will let the user determine if any data is available in the serial input buffer.

Serial buffer clear function: serial_flush() will let the user clear all data from the serial buffers.

Serial input function: serial_in() will let the user read data from the serial input buffer one byte at a time.

Serial output function: serial_out() will let the user output formatted serial.

This function will:

1. Return the number of characters sent to the USART or a negative number if an error occurred.

2. Accept as that first parameter a string with N data format symbols: This will be a string of characters contained within double quotes, containing text to output and conversion symbols for outputting specially formatted data that is contained in the subsequent parameters.

3. Accept as subsequent parameters, data1, data2, ...

dataN: a list of raw data types that will be converted to printable characters indicated by the conversion symbols in the first parameter string.

4. Will use the following conversion symbols in the first parameter string:
   a. %c – print an ASCII character.
   b. %s – print a character string.
   c. %d or %i – print a decimal integer.
   d. %x or %X – print a hexadecimal integer. Note that we usually precede this with the characters 0x%X to output, for instance, if the hexadecimal number is 5A, the output will be 0x5A. Using 0x%x will output 0x2a.
5. Will use the following control characters:
   a. \n – print a new line.
   b. \" – print a quotation mark.
   c. \\ - print a forward slash.

Serial Library API (Application Programmers Interface)

The API tells the user how to use the functions in an application. For avrtoolbox, we will create the API by using doxygen (discussed in the January '11 Smiley's Workshop) to provide comments in the header file. These comments will be extracted into html and chm help files. The user should only need to read these help files to use the library functions. This means that the user should never have to look at either the contents of the header or the C source files. This is, of course, the great value of an API: It allows you to use the functions without ever seeing the code for the function.

The API provides a sort of contract between the function writer and the user. The writer promises that the function will behave as shown in the API and the user trusts that any changes or bug fixes to the function won't affect how the function is used. The API generally specifies what parameters a function will take and what data it will return. The following is the serial library initial API. However, the user should consult the API document in avrtoolbox for the latest serial library API information before using these functions.

serial_begin()
Description: Sets up the serial communication with the transmission data rate (baudrate).
Syntax: serial_begin(baudrate).
Parameters: Baudrate: 32-bit integer (uint32_t). Recommended that you only use one of the standard rates of: 300, 1200, 2400, 4800, 9600, 14400, 19200, 28800, 38400, 57600, or 115200.
Returns: Nothing.
Example:
```
void setup()
{
       // Set up serial port for 57600 baud
       serial_begin(57600);
}
```

serial_end()
Description: Returns the serial communications elements to their default values.
Syntax: serial_end().
Parameters: None.
Returns: Nothing.
Example:
```
void shut_down()
{
       serial_end();
       sleep();
}
```

serial_available()
Description: Gets the number of bytes that have arrived from the serial port and are available for reading from the 128 byte buffer.
Syntax: serial_available().
Parameters: Nothing.
Returns: uint8_t bytes available in the serial receive buffer — up to 128.
Example:
```
void loop()
{
       if(serial_available() > 16)
{
    process_serial_input();
}
}
```

serial_flush()
Description: Clear out any data in the serial buffer. Subsequent calls to serial_in() or serial_available() will only return data that has arrived since the call to serial_flush().
Syntax: serial_flush().
Parameters: Nothing.
Returns: Nothing.
Example:
```
// Received unknown command, restart the
conversation
serial_out("Unknown command: %d, flushing
buffer.", last_command);
// Throw out everything
serial_flush();
```

serial_in()
Description: Inputs incoming serial data one byte at a time, returns –1 if no data is available.
Syntax: serial_in().
Parameters: Nothing.
Returns: 16-bit signed integer (int16_t) - the first byte of incoming data or returns –1 if no data is available.
Example:
```
// Define and receive a serial byte
int16_t myByte = serial_in();

// Is it '!'
if(myByte == '!')
{
    process_exclamation();
}
```

serial_out()
Description: Outputs formatted data based on conversion symbols and escape character sequences contained in a string of text.
Syntax: serial_out(string_with_N_data_format_symbols, data1, data2, ... dataN).

Parameters:
First parameter: String with data to format.
Following parameters: The data to be formatted for printing in the first parameter string.
Returns: The number of characters printed or a negative number if an error occurred.
Note:
Conversion symbols:
%c – print an ASCII character.
%s – print a character string.
%d or %i – print a decimal integer.
%x – print a hexadecimal integer. Note that we usually precede this with the characters 0x to output, for instance if the hexadecimal number is 5A, the output will be 0x5A.

Control characters:
\n – Print a new line.
\" – Print a quotation mark.
\\ - Print a forward slash.

Example 1:
```
uint8_t my_char = '!';
uint8_t my_string[] = { 'H', 'e', 'l', 'l', 'o',
0};
my_byte = 42;

serial_out("Print a character: %c, a string: %c,
a decimal integer: %d, a hexadecimal integer:
0x%X, a forward slash: \\, a quote: \", a new
line: \n next line.", my_char, my_string,
my_byte, my_byte);
```

which shows in the terminal as:

```
Print a character: !, a string:
Hello, a decimal integer: 42, a
hexadecimal integer: 0x2A, a
forward slash \, a quote ",
and a new line:
next line.
```

Example 2:
```
uint8_t  my_day = 21;
uint8_t my_month[] =
{'J','u','l','y',0};
uint16_t my_year = 1980;

serial_out( "Your date of birth
is:\n Day %d \nMonth: %s
\nYear %d.", my_day, my_month,
my_year);
```

which shows in the terminal as:
Your date of birth is:
Day 21
Month July
Year 1980

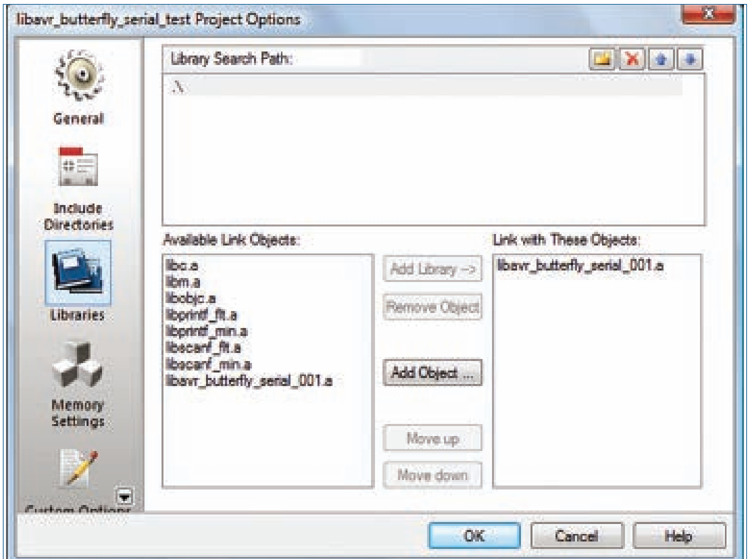
NOTE: More advanced users may note that this is a macro wrapper for the standard library printf() function with the string stored in Flash and the output directed to the USART, but the documentation here is kept simple for use by novices. If you want to use floating point conversions – DON'T. That facility is not included since it causes the code size to increase more than is warranted by the convenience. If you really need floating point, consider using the special printf() functions as documented in avrlibc.

Running Over the Buffer

After I built the serial library, I wrote a program that I thought provided reasonable testing of all the functions. Everything worked fine and then as I was about to wrap things up, I decided to push things a bit and see if I could choke the buffers, and what would happen if I did. Thankfully, nothing crashed, and based on the underlying code, I didn't expect it to, but you never know until you test. I found that if I sent a string greater than the buffer size (64 bytes in the test case) or if I called the function twice in succession with the total bytes being too high, I'd get some random output until the background interrupt had a chance to catch up. Look at the string in:

```
serial_out("serial_printf Now is the time for
all good men to come to the aid of their
country.\n",0);
```

You might think this is a reasonable test and if you took typing lessons you might even feel a bit nostalgic, but this string is over 80 bytes and will choke the buffer. Since this library is intended for novices who might think that this is a reasonable sentence, I decided to add a feature that would allow long strings to be printed without



■ FIGURE 2. Project Options.

choking the buffer. The mechanism I chose has a drawback in that if you try to transmit more than 2/3 of the buffer size, then the function will insert a brief delay after each character until the system catches up [10 ms for the Atmega328, which is running at 16 MHz and 20 ms for the Butterfly, which is poking along at 2 MHz].

The 2/3 buffer size was selected empirically because 2/3 works but 3/4 doesn't. This delay isn't particularly noticeable, but as a word of advice to folks who actually RTFM, don't send strings larger than 2/3 of your maximum buffer size if you have any kind of time constraints in your program.

Library Test Application: serial_tester

The avrtoolbox libraries will each have an application that tests the functions (and as a byproduct, demonstrates how to use the functions). The test application will assure that the functions do what is stated in the FRS, according to the API. In a large project with lots of human resources available, software testing is often the job of several people who design rigorous test cases and thoroughly examine every problem they can foresee. This is, of course, very expensive and not really needed for a small project like ours. Proper testing is a subjective task and we will let the common sense of the developer prevail. Since this is an open source project, if a problem shows up that wasn't covered in the tests (they will), then the user can file a report in the 'issues' section of the project and someone working on the project may eventually get around to looking at it.

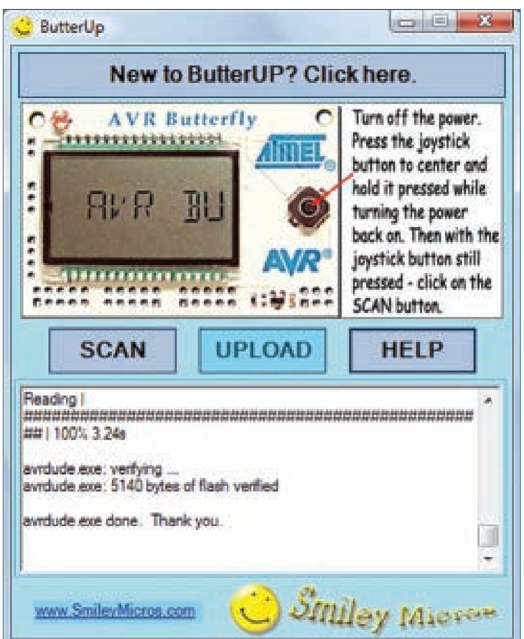
Since libraries can sometimes be device-dependent, we will create separate libraries tested for each of our avrtoolbox common devices and development platforms: Atmega169 (Butterfly); Atmega328 (on an Arduino board); and the Atmega644 (on the BeAVR). We will call the libraries libserial_butterfly001.a; libserial_atmega328; and libserial_atmega644.a.

You can find the serial_tester AVRStudio project and the serial library archives and source code in the avrtoolbox project source code trunk or at: **http://tinyurl.com/3cc7qz**, and the serial_tester code at **http://tinyurl.com/3jxf5z6**. Load the serial_tester project in AVRStudio then load the library archive as follows.

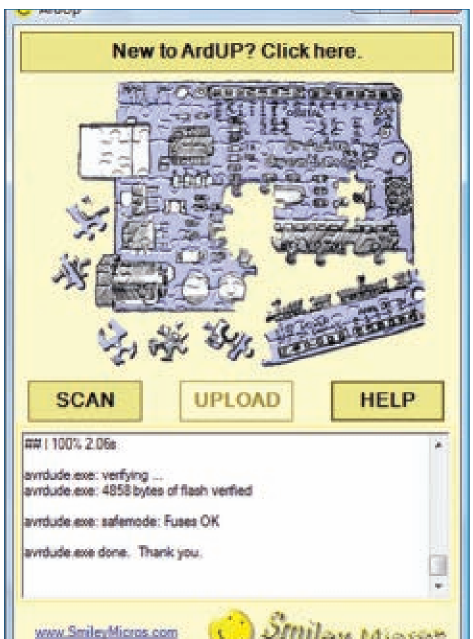
Using the Libraries with AVRStudio

Let's use the libserial_butterfly_001.a as an example. [If you have an Arduino, you can use the libserial_mega328_001.a.] Make sure that the library is in the same sub-directory as your AVRStudio project .aps file. Then, open the AVRStudio Project menu and select the Project Options. Click on the libraries icon to open the window shown in **Figure 2**. In the upper part of this window, click on the little folder icon (left of the red X) and navigate to your project folder.

It will show ".\" in the upper text box and it will also locate the libserial_butterly001.a file and show it in the 'Available link Objects:' list below. Highlight the library, then click the 'Add Object' button to add it to the 'Link with these objects' list. Click okay and compile the project to generate the .hex file for uploading to the Butterfly.



■ FIGURE 3. ButterUp .hex file uploader.



■ FIGURE 4. ArdUp .hex file uploader.

Uploading the .hex File

You can use avrdude as shown in Smiley's Workshop in the May '09 *Nuts & Volts*.

However, if you want to try something a bit different you can use the uploaders I am working on that put a C# IDE over avrdude, making it a bit easier to use. You can get them in the avrtoolbox pc_applications section. You navigate to this directory by opening **http://code.google.com/p/avrtoolbox/source/browse/**, then click on trunk and then pc_applications. These are beta releases, so take that under advisement.

ButterUp

ButterUp comes with a user manual and rather than waste trees here, I suggest you just click on the button 'New to ButterUp? Click here.' shown at the top of **Figure 3**. If you make a mistake, the manual .pdf file will automatically be opened which is sort of like yelling RTFM and then pushing it into your face. (Annoying yes, but then again, if you weren't making mistakes you wouldn't need the manual, would you?)

ArdUp

Like for ButterUp, I suggest you just click on the button shown at the top of **Figure 4** to find out how to use it. This program is similar to ButterUp but uses the DTR modem line to reset the Arduino, so that it goes directly to the bootloader for use by avrdude. Try and keep in mind that we are using the Arduino board as a generic Atmega328 development platform and not using it as an 'Arduino.' If you find this concept confusing, please consult the '*Moving Beyond the Arduino*' stuff in the May '09 issue.

If you do use either of these, I'd like to hear if you have any problems. You can start a thread on AVRFreaks with either ButterUp or ArdUp in the title, or you can open an issue in the avrtoolbox project.

Running the Test In Bray's Terminal

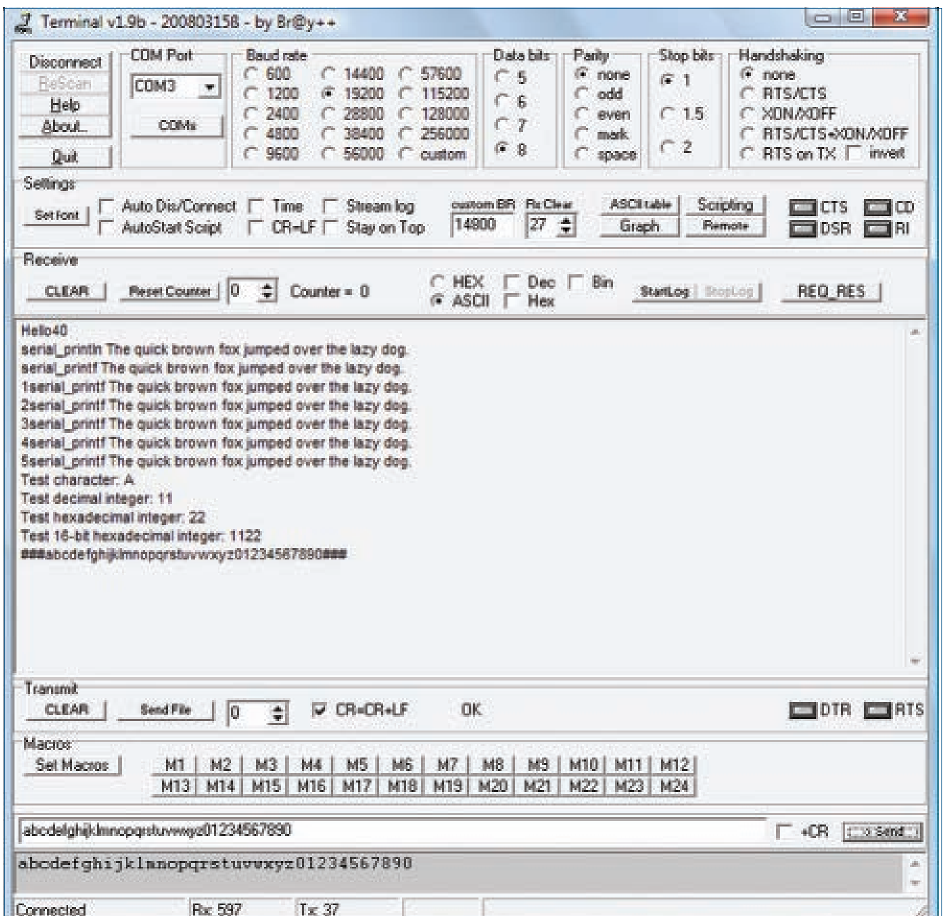
Open Bray's terminal as shown in **Figure 5**. If you are using a Butterfly, make sure the baud is set to 19200 and click the joystick up to get the application to run. If you are using the Arduino board, make sure the baud is 57600; you may need to click the DTR button on Bray's on and off (or just press the reset button on the board). Once the test output prints, then you can send some characters via the send window. In the case in **Figure 5**, I sent "abcdefghijklmnopqrstu vwxyz01234567890" and — as you can see —everything Rx'd and Tx'd just fine.

Please note for the AVR Butterfly: This marvelous little board uses a 32.768 kHz watch crystal to keep track of real time and to calibrate the internal RC oscillator to 2 MHz. Since the RC oscillator isn't particularly accurate, you can't use just any old baudrate and expect it to work consistently.

For this reason, the serial library for the Butterfly is hardwired for 19200 baud and even if you enter another value in the serial_begin(baud) function, if you are using the libserial_butterfly001.a, it will ignore the baud value and use 19200. Also, the Butterfly tries to run the application twice when you toggle the joystick up: once when it goes up and once when it comes down, so you may get a partial start before the real start in Bray's terminal.

If after all this good stuff you just can't wait and want to get a good leg up on real C programming and the AVR (while helping support your favorite magazine and technical writer), then buy my C Programming book and Butterfly projects kit from the *Nuts & Volts* website.

Next month, if all goes well, we will continue with avrtoolbox by learning about how to buffer data and writing a ring (a.k.a. circular or FIFO) buffer. **NV**



■ FIGURE 5. serial_tester results in Bray's Terminal.

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NEW PRODUCTS

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EVAL PLATFORM FOR **BRUSHLESS MOTORS**

Texas Instruments, Inc., has introduced a complete motor control evaluation kit for spinning brushless DC (BLDC) and permanent magnet synchronous (PMSM) motors. The DRV8312-C2-KIT is a high performance, power efficient, and cost-effective sensorless field-oriented control (FOC) and trapezoidal commutation platform. It spins motors out of the box, speeding development of sub 50-V and 6.5-A brushless motors for driving medical pumps, gates, lifts, and small pumps, as well as industrial and consumer robotics and automation.

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• Flexible control platform that supports sensorless FOC, and sensorless and sensored trapezoidal commutation control for rapid evaluation and development of three-phase motors. By adding a separate shaft encoder, the DRV8312-C2-KIT can also support sensored FOC.

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• C2000 Piccolo MCU performs control, communications, and debug functions. The industry-leading 32-bit C2000 MCU integrates the most advanced analog feedback, digital control peripherals, and CPU capability in an embedded MCU device family starting under $2. This includes access to the most thorough set of motor control software modules, real-time debug capabilities, and open-tooled reference designs via free controlSUITE™ software.

The DRV8312-C2-KIT is available now for $299. This price includes CCStudio IDE with no compiler or memory limitations. All documentation, software source, and the hardware development package — including bill of materials, schematics, and Gerbers — is freely available through controlSUITE.

A complete evaluation kit based on the DRV8412 motor driver is also available for spinning brushed DC and stepper motors. The DRV8412-C2-KIT is priced at $299.

For more information, contact:
Texas Instruments
Web: **www.ti.com**

■ BY FRED EADY

Pedaling the STC12C5A60S2 from STC Microcontroller

The multiple variants of the original 8051 core are like a bunch of bicycles. Once you learn to ride one, you can ride them all. That's a good thing because this time around, we're going to put our feet on the pedals of yet another version of the good old 8051 microcycle. The STC12C5A60S2 we are about to discuss is manufactured by STC Microcontroller and is an enhanced version of the 80C51. The 8051 microcontroller needs no introduction. So, let's get down to moving some electrons with the STC12C5A60S2.

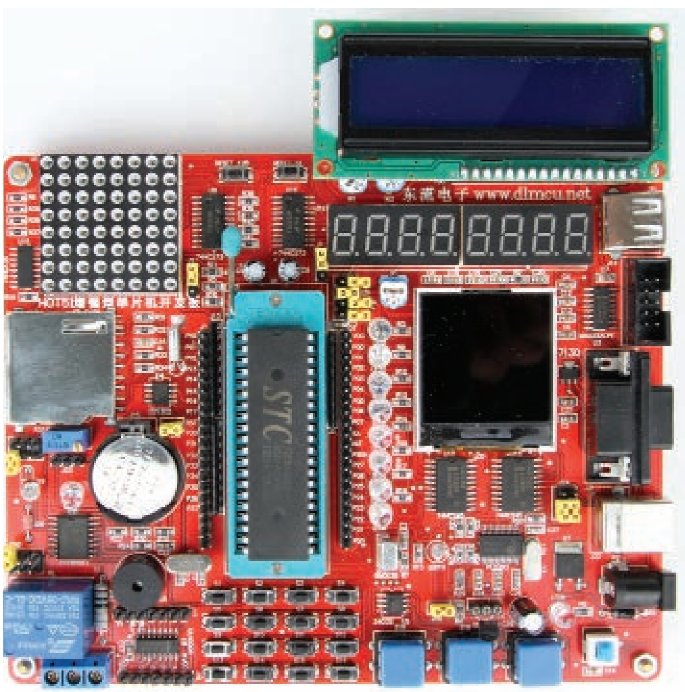
STC12C5A60S2 SUPPORTING HARDWARE

The base STC12C5A60S2 (STC12 for short) hardware we will be working with exists in the form of an STC51 EVK-Pro professional evaluation kit which is the object of affection in **Photo 1**. As you can see, the EVK-Pro eval kit is a seriously busy electronic package. In addition to the ZIF-socketed STC12 microcontroller, the kit visuals include two banks of four-digit seven-segment LED displays, a color LCD module, an LED matrix module, a 16 x 2 LCD, and an eight-bit row of variously colored super bright blinkers.

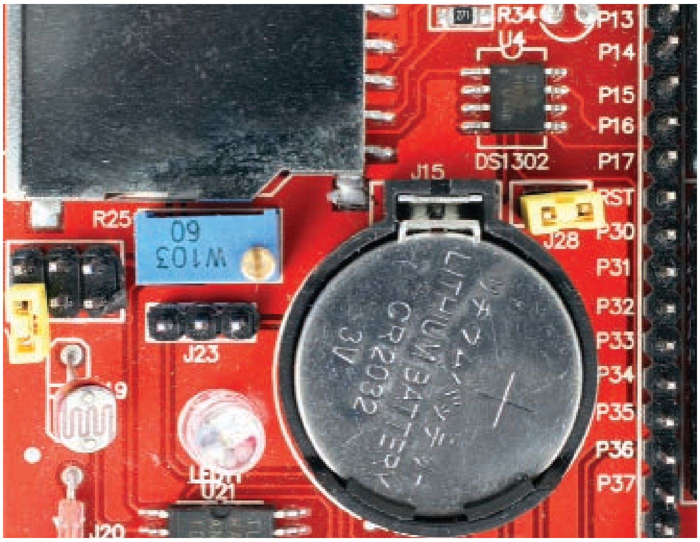
If you have a thing for buttons, the STC51 EVK-Pro kit sports a 16-button matrix arranged as a 4 x 4 keypad and three large individually addressed momentary pushbuttons that will delight your index fingers. If that's not enough for you, a 21-button IrDA remote module and supporting HS0038 IrDA sensor are also part of the package.

Chances are this ain't your first microcontroller rodeo. So, you already realize that embedded devices tend to lean towards monitoring and control applications. Well, the STC51 kit is no exception. On the monitoring side of the embedded arena, an eight-bit I^2C-equipped analog-to-digital/digital-to-analog converter in the guise of a PCF8591 keeps watch over a potentiometer, photoresistor, and thermistor. If you have embedded monitoring ideas of your own, you can override the aforementioned variable resistance devices attached to the PCF8591 and wire your desired array of sensors into the PCF8591's analog inputs. In addition to the PCF8591/thermistor combination, the STC51 eval kit offers an alternate means of temperature sensing with the inclusion of an on-board MAXIM DS18B20 1-Wire digital thermometer.

The embedded control components at the other side of the embedded arena are under the control of a high current ULN2003 Darlington array. Four of the seven 500 mA Darlington pairs terminate at a five-pin connector that is designed to provide drive for the coils of the stepper motor that is an integral part of the evaluation kit. A separate Darlington pair provides drive for the five volt



■ PHOTO 1. This is one busy piece of electronic hardware. Like everything complex, it becomes simple when digested in smaller portions.



■ PHOTO 2. The DS1302, a 32.768 kHz crystal, and an optional backup power source are all we need to allow an STC12C5A60S2 application to keep time.

coil of a 10 ampere SPDT relay. A standard brushed DC motor also made its way into the EVK-Pro kit, and through a two-pin connector it claims yet another of the ULN2003's Darlington arrays. If the clicking of mechanical relay contacts and the hum of motors isn't enough noise for you, a piezo buzzer is attached to the last available ULN2003 Darlington pair.

A certified RS-232 portal is always nice to have. These days, having a regulation USB interface back up that RS-232 portal is even better. In the case of the EVK-Pro kit, its USB interface does double-duty as a powered serial communications conduit and an STC12 ISP (In System Programming) portal. The STC51 EVK-Pro kit's USB port is unique as it isn't based on an FTDI part. Instead, we'll be working with Prolific's PL-2303 USB to serial bridge controller. For those of you that are used to working with FTDI USB parts, you will find that the Prolific IC has the same touch and feel as its FTDI counterparts.

A schematic representation of the evaluation kit can be had for a download from the STC website. The downloadable schematic breaks the kit down into the individual subsystems we have mentioned thus far. You may want to download the schematic too as it will come in handy when we discuss the inner workings of the STC12's firmware.

STC12C5A60S2 SOFTWARE TOOLS

All of our STC12-based application firmware will be generated using the Keil C51 C compiler. The Keil compiler is an excellent C compiler and a breeze to use thanks to its µVision IDE. To make our job even easier, the folks at STC Microcontroller provide a set of canned STC12 firmware drivers and examples for the electronic devices loaded on the EVK-Pro evaluation kit printed circuit board (PCB). In addition to the firmware, a custom STC12 header file (STC_NEW_8051.H) and an STC12-specific µVision CDB file are freely available to us via the STC website. In that the evaluation kit's USB interface doubles as an ISP programming portal, a specialized STC12 hardware programming tool is not required. The free PC-based STC MCU ISP application accepts a compiled hexadecimal STC12 firmware image generated by the Keil compiler and transfers it via USB to the STC12's Flash program memory area. Thus, the STC12 never has to leave its ZIF socket to be programmed.

If you choose not to employ USB in the STC12 programming process, the free downloadable STC MCU ISP application can be utilized via the EVK-Pro eval kit's RS-232 port. Take a look at the PL-2303 area of the kit schematic and you'll see that the STC12's UART communications pins are easily redirected from the PL-2303 to the MAX232 with the movement of a couple of jumpers.

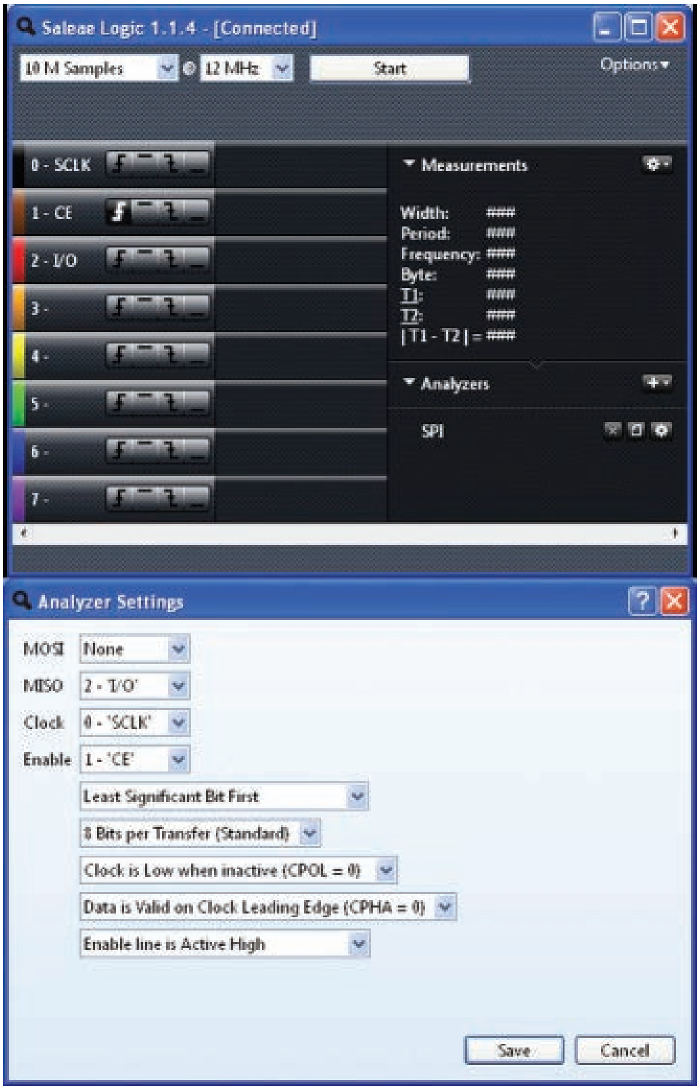
IT'S TIME

And, the STC51 EVK-Pro kit has it. With the assistance of the Keil compiler, the STC MCU ISP application, a Saleae logic analyzer, and some canned STC12 firmware, we will coax the date and time out of the eval kit's on-board DS1302 real time clock IC. The RTCC hardware area is under the lens of my Canon in **Photo 2**.

Here's the setup. The Saleae logic analyzer taps into the DS1302's SCLK, I/O, and CE lines as shown in the upper portion of **Screenshot 1**. The DS1302 communicates in an SPI-like manner and closely emulates an SPI slave device. So, we can take advantage of the logic analyzer's built-in SPI analyzer to automatically decode the DS1302's incoming and outgoing message traffic. If you peruse the DS1302 datasheet, you'll find that all of its register definitions are laid out in an eight-bit format. **Figure 1** is a field-by-field view of the DS1302 RTCC register set. According to **Figure 1**, we can climb up on our donkey and declare that the DS1302 is an eight-bit device, as far as communicating with it is concerned. A typical DS1302 message consists of 16 bits of command/data information delineated by the active-high CE signal.

The DS1302 wants to see the least significant bit of the incoming message data stream first. Data bits within the inbound DS1302 messages must be valid at the rising edge of each SCLK pulse. Outgoing DS1302 data bits are delivered at the falling edge of SCLK. Don't get concerned about which edge does what as the canned DS1302 read and write routines are written to assure that data is read and written between the rising and falling edges of an SCLK pulse.

The lower portion of **Screenshot 1** configures the logic analyzer's SPI analyzer engine and reflects all of the aforementioned DS1302 message and communications link attributes. The DS1302 command byte structure is converted into individual bits in **Figure 2**. Note that I have



■ SCREENSHOT 1. The upper half of this screenshot is under the control of the rules set forth in the lower half of the capture.

configured the SPI analyzer to trigger on the rising edge of the CE signal. That way, no matter when we start the logic analyzer we will be sure to start the capture at the beginning of a DS1302 message frame.

PUTTING TIME IN A BOTTLE ... SORTA'

The upper frame of **Screenshot 2** is a logic analyzer decode of the STC12 writing time and date information to the DS1302. I performed this capture by holding the STC12 in reset and starting the logic analyzer session. At time marker 0.0 mS, the CE signal was asserted by the STC12 and SCLK pulses began to clock data out of it.

The first message frame transmits a decimal 142 followed by a zero. Decimal 142 is equivalent to 0x8E hexadecimal. Consulting **Figure 1**, we find that 0x8E is a write operation to register 0x07 with a data payload of 0x00. This operation clears the WP (Write Protect) bit which allows data originating from the STC12 to be written into the DS1302's registers.

With the DS1302 registers open for business, the next frame is aimed at register 0x00. A couple of things occur simultaneously when 0x00 is loaded into the 0x00 register. The CH (Clock Halt) flag is cleared which allows the DS1302 to exit low power standby mode and activate its clock oscillator. The rest of the 0x00 data clears the seconds register.

The time and date initialization frames continue until 0x80 is written to register 0x07 which occurs following the write to register 0x8C. Writing register 0x07 with 0x80 sets the WP bit. Using **Figures 1** and **2** to decode the remaining visible frames in the upper frame of **Screenshot 2**, you will see that the DS1302's calendar has been set for Wednesday (Day 4 of the week) June 1, 2011. The time is set to display in a 24 hr format with the initial time set to 00:00:00 hours. The original canned DS1302 application does not initialize the clock calendar. So, here's the code I added to enter the time and date data:

```
time.second = 0;      //initialize seconds to 00
                      //and clear CH bit
time.minute = 0;      //initialize minutes to 00
time.hour = 0;        //initialize hours to 00
                      //and 24hr format
time.day = 1;         //initialize date to 01
time.month = 6;       //initialize month to June
time.week = 4;        //June 1 = Wednesday =
                      //day 4
time.year = 11;       //June 1 = Wednesday in
                      //year 2011
DS1302TimeSet(time); //DS1302 time set function
```

Before we examine the code that assembled and transmitted the message frames, I'm sure you're trying to get the decimal year value of 11 out of decimal 17 in that final visible frame. The DS1302's time and date registers want to see time and date data in BCD (Binary-Coded Decimal) format.

READ	WRITE	BIT 7	BIT 6	BIT 5	BIT 4	BIT 3	BIT 2	BIT 1	BIT 0	RANGE
81h	80h	CH	10 Seconds			Seconds				00–59
83h	82h		10 Minutes			Minutes				00–59
85h	84h	12/$\overline{24}$	0	10 / AM/PM	Hour	Hour				1–12/0–23
87h	86h	0	0	10 Date		Date				1–31
89h	88h	0	0	0	10 Month	Month				1–12
8Bh	8Ah	0	0	0	0	0	Day			1–7
8Dh	8Ch	10 Year				Year				00–99
8Fh	8Eh	WP	0	0	0	0	0	0	0	—
91h	90h	TCS	TCS	TCS	TCS	DS	DS	RS	RS	—

■ FIGURE 1. The DS1302 RTCC registers are laid out in this manner. Be aware that the DS1302 requires the time and date registers to be read and written in BCD format.

■ FIGURE 2. The READ and WRITE columns of Figure 1 reflect this bit pattern.

7	6	5	4	3	2	1	0
1	RAM / $\overline{\text{CK}}$	A4	A3	A2	A1	A0	RD / $\overline{\text{WR}}$

So, walk that decimal 11 through this decimal-to-BCD conversion function with the argument *dec* represented by decimal 11:

```
uchar DECToBCD(uchar dec)
{
        uchar bcd;
        bcd = 0;
        while(dec >= 10)
        {
                dec -= 10;
                bcd++;
        }
        bcd <<= 4;
        bcd |= dec;
        return bcd;
}
```

The decimal-to-BCD function returns a BCD value of 11 which in hexadecimal format is 0x11 or decimal 17. The translation from decimal to BCD occurs within the DS1302 time set function:

```
void DS1302TimeSet(struct time time)
{
DS1302WriteData(0x8E,0);//close write protect
DS1302WriteData(0x80,DECToBCD(time.second));
//set second
DS1302WriteData(0x82,DECToBCD(time.minute));
//set minute
DS1302WriteData(0x84,DECToBCD(time.hour));
//set hour
DS1302WriteData(0x86,DECToBCD(time.day));
//set week
DS1302WriteData(0x88,DECToBCD(time.month));
//set month
DS1302WriteData(0x8A,DECToBCD(time.week));
//set day
DS1302WriteData(0x8C,DECToBCD(time.year));
//set year
DS1302WriteData(0x8E,0x80);//open write rotect
}
```

Okay. At this point, the DS1302's oscillator is active and the clock is running. The lower frame of **Screenshot 2** is a result of my randomly starting a logic analyzer capture. Another glimpse at **Figure 1** reveals that as far as hexadecimal values are concerned, a DS1302 register read command value is simply an incremented DS1302 register write command. With that, the frame immediately following the release of the WP bit is a read register 0x00 command that returns 06 seconds. The most significant bit of register 0x00 represents the CH flag bit which must be set for the clock to run. Since the seconds register tops out at a BCD 59, the most significant bit is never read as part of the seconds data. Decoding the rest of the data in the visible frames results in a time of 00:02:06 and a calendar date of June 1, 2011, which happens to fall on Day 4 — a Wednesday. Here's the STC12 code behind retrieving the current date and time:

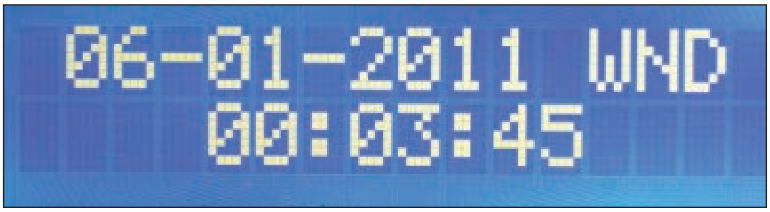
```
struct time DS1302TimeGet(void)
{
struct time time;
DS1302WriteData(0x8E,0);//close write protect
time.second = BCDToDEC(DS1302ReadData(0x81))
//get second
time.minute = BCDToDEC(DS1302ReadData(0x83));
//get minute
time.hour = BCDToDEC(DS1302ReadData(0x85));
//get hour
time.day = BCDToDEC(DS1302ReadData(0x87));
//get week
time.month = BCDToDEC(DS1302ReadData(0x89));
//get month
time.week = BCDToDEC(DS1302ReadData(0x8B));
//get day
time.year = BCDToDEC(DS1302ReadData(0x8D));
//get year
DS1302WriteData(0x8E,0x80);//open write protect
return(time);
}
```

As you've already ascertained, the BCD-to-decimal conversion comes in the form of a function that is called from within the DS1302TimeGet function:

```
uchar BCDToDEC(uchar bcd)
{
        uchar dec;
        dec = bcd & 0x0F;
        bcd = bcd & 0x70;
        dec += bcd >> 1;
        dec += bcd >> 3;
        return dec;
}
```

As you can see in **Photo 3**, the date and time data

■ SCREENSHOT 2. The upper Saleae logic analyzer frame captures the STC12C5A60S2 writing time and date information to the DS1302. A random capture of the DS1302 delivering the time and date to the STC12C5A60S2 is archived in the lower logic analyzer frame.



■ PHOTO 3. Most of the code behind this photo is part of the free STC51 EVK-Pro professional evaluation kit firmware package. I documented my code modifications in the DS1302 main.c source file that is part of this month's download package.

retrieved from the DS1302 is displayed in real time on a 2 x 16 LCD. The LCD driver is part of the STC51 evaluation kit's canned firmware package. I made some minor modifications to the original DS1302 application code. You can download my modified version of the code from the *Nuts & Volts* link.

1-WIRE ... THE STC12C5A60S2 WAY

In addition to SPI, the Saleae logic analyzer also speaks 1-Wire. Behold **Screenshot 3**, which is a logic analyzer capture of the STC12 initiating a DS18B20 temperature capture using the 1-Wire protocol.

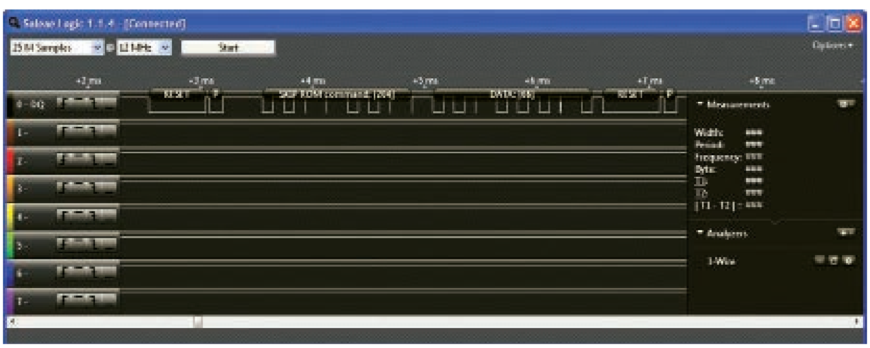
The DS18B20 datasheet tells us that a DS18B20 transaction consists of a reset, followed by a ROM command and a DS18B20 Function command. The STC12 must force the DS18B20's DQ line logically low for more than 480 µS to initiate a DS18B20 RESET. At the end of the RESET pulse, the STC12 relinquishes the DQ line and waits for a presence reply from the DS18B20. The DS18B20 issues a presence signal by taking the DQ line low for a period of time. The presence signal is an indicator to the STC12 that the DS18B20 is online, or on wire.

Now that the STC12 knows a DS18B20 is at the other end of the wire, a ROM command can be issued. ROM commands allow the master device to single out a specific DS18B20 based on the unique 64-bit ROM codes. If more than one DS18B20 is on the wire, the master can also issue ROM commands to determine how many devices are on the wire. There may be other 1-Wire devices on the wire in addition to a DS18B20. The master device has access to ROM commands that allow the master to identify what types of devices it is communicating with. In our case, the STC12 issued a SKIP ROM command. The SKIP ROM command (0xCC) allows the master to address all of the devices on the wire simultaneously without the need for 64-bit ROM codes. The DS18B20 Function command that follows the SKIP ROM command will be broadcast to every device on the wire. According to our logic analyzer capture, the DS18B20 Function command is a byte of data with the value of 68 decimal. Consulting the DS18B20 datasheet, the byte containing decimal 68 is a Convert T command. A Convert T command initiates a single DS18B20 temperature conversion. Upon completion of the conversion, the temperature data is stored in the two-byte temperature register located in the scratchpad memory area.

Screenshot 4 contains the logic levels necessary to retrieve the temperature data and the temperature data itself. The required RESET pulse is issued and the DS18B20 responds with a presence pulse. Again, the STC12 issues a SKIP ROM command. Broadcasting the Read Scratchpad command (190 decimal/0xBE) is okay here since only a single DS18B20 is on the wire. The first byte of data retrieved is the least significant byte of the temperature data. So, we end up with a temperature value of 0x0195. Let's use **Figure 3** to convert the hexadecimal temperature value to degrees Celsius:

```
0x01 = 16 (+ sign)
0x95 = 8 + 1 + 0.25 + 0.0625

Temperature in Degrees Celsius =
+25.3125
```

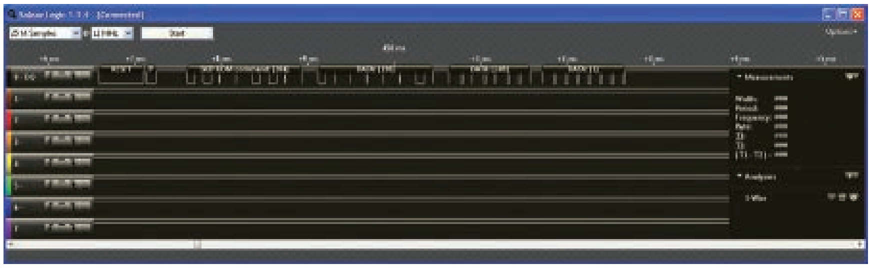


■ SCREENSHOT 3. The 1-Wire protocol can be described as logic toggling on a schedule. The Saleae logic analyzer 1-Wire analyzer engine makes the DS18B20 datasheet timings and commands a bit easier to understand.

	BIT 7	BIT 6	BIT 5	BIT 4	BIT 3	BIT 2	BIT 1	BIT 0
LS BYTE	2^3	2^2	2^1	2^0	2^{-1}	2^{-2}	2^{-3}	2^{-4}
	BIT 15	BIT 14	BIT 13	BIT 12	BIT 11	BIT 10	BIT 9	BIT 8
MS BYTE	S	S	S	S	S	2^6	2^5	2^4

S = SIGN

■ FIGURE 3. The DS18B20 temperature value is a 16-bit sign-extended two's complement number. To obtain the Celsius temperature, the STC51 EVK-Pro professional evaluation kit's DS18B20 firmware driver simply adds the power-of-2 bit values just as we did.



■ SCREENSHOT 4. The converted temperature data is stored in the first two bytes of the DS18B20 scratchpad memory area. All we have to do is issue a read and pick up the first two bytes we see.

If you haven't done so by now, go to the STC Microcontroller website and download the STC51 EVK-Pro professional evaluation kit firmware package. The code behind the Saleae Logic Analyzer 1-Wire capture is located in the DS18B20 project folder. Now that you've seen the actual 1-Wire bits wiggle in the logic analyzer 1-Wire capture, you should have no trouble matching the wiggling bits to their associated STC12 firmware functions.

A PURE MICROCONTROLLER

Like its 80C51 predecessor, the STC12C5A60S2 is a pure microcontroller. Even a simple STC12 program for flashing LEDs is devoid of the fluff found in the code of more "sophisticated" microcontrollers. The EVK-Pro eval kit hardware is basic enough for a beginning 8051 designer and advanced enough for serious STC12 development. The extensive firmware support, ISP programming capability, and hardware base make the STC12C5A60S2 an easy addition to your design cycle. **NV**

Fred Eady can be reached at fred@edtp.com.

SOURCES

STC Microcontroller
STC12C5A60S2
STC51 EVK-Pro Professional Evaluation Kit
www.stc-51.com

Keil
Keil C51 C Compiler
www.keil.com

MAXIM Integrated Products, Inc.
DS1302
DS18B20
www.maxim-ic.com

Saleae Logic
Saleae Logic Analyzer
www.saleae.com

ELECTRONET

For the ElectroNet online, go to **www.nutsvolts.com** click ***Electro-Net***

BY LOUIS E. FRENZEL W5LEF

NEW COMMUNICATIONS DEVICE: THE TABLET COMPUTER

If you are contemplating the purchase of one of the hot new tablet computers, you had better first consider just what you are going to do with it. Yes, it is a computer, but not in the usual sense. While a PC is widely used for office and other related applications like word processing, data bases, spreadsheets, accounting, and other applications, the tablet is mainly a communications device. Tablets don't do office related stuff. Instead, a tablet's strong suit is Internet access, email, web browsing, and access. It is also good for photos, audio, and video. You cannot make phone calls on it, of course, but you would not want to give up your cell phone for that anyway. If you are looking for an additional supplementary communications device, a tablet may be a good choice. Here are some facts to consider if you are seriously shopping for a tablet.

TABLET VS. LAPTOP

Laptops and their smaller relatives, the netbooks, have been outselling desktop computers the past couple of years. They do everything a desktop does, but are smaller and more portable. Mobile and convenient. With 11 to 17 inch screens and a weight of three to seven pounds, they are still a handful. The smaller netbooks are lighter and have smaller screens, so are easier to carry around. They have less memory but that is not a disadvantage for many applications. The biggest complaint is the smaller, more cramped keyboard that is less convenient for typing. That may not be a disadvantage either, if you are not keyboarding lots of data or other input.

What do people do with their PCs today? Is it really office type applications? I think not. What do you do mostly with your PC these days? Email and Internet access is probably 90% or more of it. If that is the case for you, what you really need is more of a communications device than an actual data processing or calculating machine. A tablet computer may be a good choice for you. Price-wise, the tablet is about the same cost as a mid-range laptop or high-end netbook.

TABLET VS. SMARTPHONE

A good smartphone — like the Apple iPhone and a bunch of others — will do everything a tablet will do plus make phone calls. If you don't have a smartphone yet, maybe that should be your first consideration. If your two year contract is about up, it is an excellent time to look at that option. The smartphone is the ultimate communications device with its multiband cell phone capability, Wi-Fi, Bluetooth, GPS navigation, and even FM radio in some. You can use it to text, email, access websites, and any Internet connection. Once you have one of these, you won't ever want to go back to a regular cell phone.

One big benefit of the smartphone over a tablet is that it is initially cheaper. You can get a top-of-the-line smartphone like the Apple iPhone or the Verizon Thunderbolt (**Figure 1**) for about $200 plus the mandatory two year contract. This contract has a data plan that will

■ FIGURE 1. Verizon's Thunderbolt smartphone is made by HTC. It is a 4G cell phone that uses Verizon's LTE network. It is a better communications option than a tablet computer for some.

cover all that Internet access. A tablet, on the other hand, will set you back at least $500 and you cannot make phone calls.

Just about the only downside to the smartphone is its small screen size. It is a real pain at times, although still useable. If you want to watch videos and play games, the screen is a restriction that goes away on a tablet.

THE TOP TABLET: APPLE iPAD

Tablet computers are not new. Companies like HP, Lenovo, and others have had tablets for years but they were never popular. Who knows why? When Apple introduced its iPad in June '10, however, it was almost an immediate hit. It has great functionality and Apple's usual cachet. Or, maybe the tablet's time has come. Millions of iPads have been sold at prices from $500 to over $800. In March, Apple introduced the iPad2. It too is a big hit. If you are not sure why, take a look at some of these hot features.

First, the iPad2 has a big 9.7 inch (diagonal) high resolution 1024 x 768 pixel LCD screen that is a touch screen, as well (see **Figure 2**). All operations are initiated with touch via on-screen icons. A full QWERTY keyboard is also included. Although it is not great for touch typing, it is faster and easier than the much smaller smartphone keyboards. The iPad2 comes with two cameras: a back camera and a front camera. Both can be used for still action or video up to 30 frames per second. The battery is a 25 watt lithium polymer that is good for up to about 10 hours of mixed use.

The iPad2 is also very small and light. The size is 7.3 x 9.5 inches and it's only 0.34 inches thin. Weight is only 1.35 lbs. It comes in white as well as black, and has a unique magnetic Smart Cover that protects the screen.

Processor-wise, the iPad2 uses Apple's own A5 1 GHz dual core processor. This is a derivative of the popular ARM device and is made by Samsung. You can get 16 GB, 32 GB, or 64 GB of memory if you need it.

As for I/O, the iPad2 has a built-in microphone and speaker, and a headphone jack. Other devices are a three axis gyro, an accelerometer, and an ambient light sensor. Charging and data transfer is by way of Apple's 30-pin connector and a USB port.

For audio playback, the iPad2 supports all the standard digital audio formats. Load up with iTunes and you are ready to go. Video formats include H.264 up to 30 fps in a 720p screen. Most common video features are supported, making the iPad a great video viewer for almost any content. And the iPad2 is also an e-book reader.

As for its communications capabilities, the iPad2 comes in two versions: one with and one without cellular capability. The basic unit communicates via Wi-Fi or the IEEE 802.11a/b/g/n WLAN standard wireless. It will hook up with hot spots everywhere and in your own home network. Bluetooth 2.1 with EDR is included.

The cellular enabled models come with Wi-Fi and Bluetooth, but also let you choose AT&T or Verizon as your 3G carrier. The AT&T version implements the 3G standards UMTS/HSDPA/HSUPA in the 850, 900, 1,900, and 2,100 MHz bands, and GSM/EDGE in the 850, 900, 1,800, and 1,900 MHz bands. The Verizon model provides CDMA EV-DO Rev. A in the 800 and 1,900 MHz bands. The price on these models is $820 but you can communicate from almost anywhere.

One last thing. The iPad2 will run most of the iPhone's apps. These application programs are downloadable from iTunes. There are over 350,000 available from free to several hundred dollars. This just may be one of the main reasons to buy an iPad.

If your main goal is communications, a tablet is a great choice. All laptops have built-in Wi-Fi these days, but few offer embedded cellular. You can always buy a data card or dongle to get 3G cellular connectivity on your laptop, of course.

■ FIGURE 2. The Apple iPad2 is the second generation iPad that is keeping Apple in the lead of the tablet market. The iPad2 is thin, light, and powerful. Its main function is Internet connectivity.

OTHER TABLETS

There are lots of other tablet computers to consider, as well. While Apple has over 90% of the market share right now, that is expected to drop as more

■ FIGURE 3. The Motorola Xoom, like the Apple iPad2, is mainly a communications device with both Wi-Fi and cellular connectivity. It runs the Nvidia Tegra2 1 GHz dual core processor and Google's Android operating system.

competitive tablets come along. According to some, the closest competitor is Motorola's Xoom (**Figure 3**).

It has all the similar features to the iPad2, but has a slightly larger 10.1 inch screen. It is now available from Verizon and uses their 3G CDMA EV-DO, Rev. A network. The Xoom is also said to be 4G ready for Verizon's LTE 700 MHz network, whenever that is implemented. An AT&T 3G version is also in the works. It is rumored that there will be a Sprint WiMAX 4G version, as well. The Xoom runs the Google Android operating system where there are tens of thousands of app programs available.

Other current tablets include the Samsung Galaxy Tab. The initial units have a seven inch screen but the newer ones have a 10 inch screen. Dell has the Streak, initially with a five inch screen but also coming in seven and 10 inch versions. All of these are Wi-Fi only, but are expected to get carrier and FCC approval for 3G service. RIM (the BlackBerry phone maker) also has its new PlayBook that is designed for the corporate BlackBerry crowd. And there are many others on the way.

Is there a tablet in your future? Maybe. But know this. Tablet sales have seriously affected the PC market. There is still PC/laptop growth, but it has slowed greatly the first part of 2011. The trend is clear. Tablets have taken hold and if your main application is communication, a tablet could be your next computer. **NV**

FUNDAMENTALS FOR THE BEGINNER

Build a Dual Burglar Alarm

A kit for these experiments can be purchased from the *Nuts & Volts* Webstore at **www.nutsvolts.com** or call us at **800-783-4624**.

In this experiment, we will build an useful burglar alarm circuit for normally-closed and normally-open alarm systems.

1. Build the Circuit.

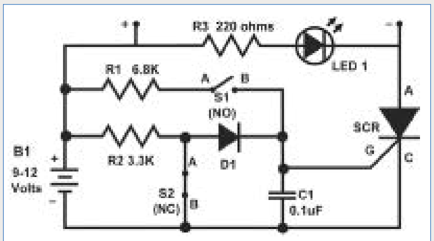
Using the schematic along with the pictorial diagram, place the components on a solderless breadboard as shown. Verify that your wiring is correct.

2. Do the Experiment.

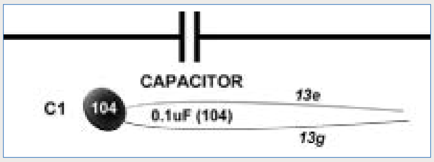
Theory: Closing switch S1 will put a positive voltage on the gate of the SCR, causing it to conduct and to sound an alarm. Or, by opening the normally-closed switch S2, capacitor C1 will discharge, putting a positive pulse on the gate of the SCR which will cause it to conduct. The only way to stop the SCR from conducting once it has started to conduct is to remove power from the circuit. Thus, even if the sensor switches S1 or S2 are opened or closed again, the alarm will not turn off. The only way to reset the alarm is to disconnect the battery.

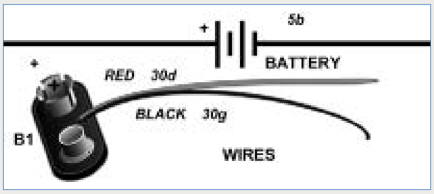
Procedure: After you have built the circuit on a solderless breadboard, connect a nine-volt battery to the battery snap. With switch S1 in the open position (wires not touching) and with switch S2 in the closed position (wires touching), the LED should NOT be lit.

Close switch S1 by touching the two wires. The LED should light up and remain lit until you disconnect the battery. If you open switch S2 (by disconnecting the two wires that are touching), the LED will also light up and remain lit until power is removed from the circuit.

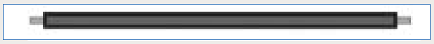


SCHEMATIC

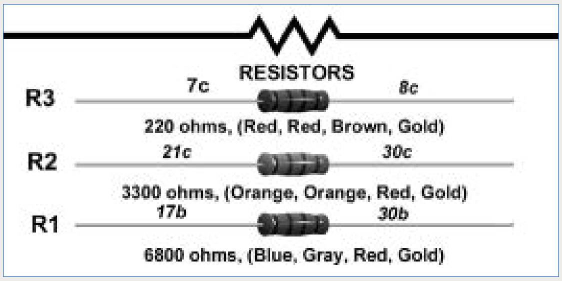


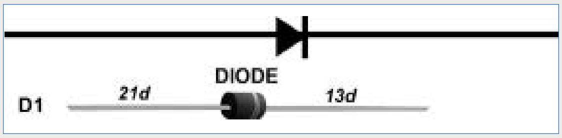


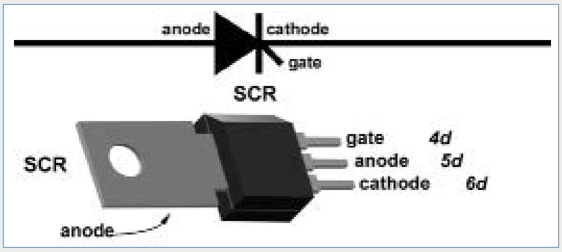
WIRES

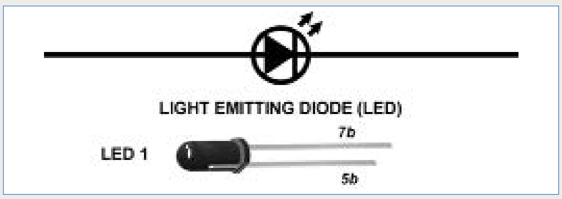


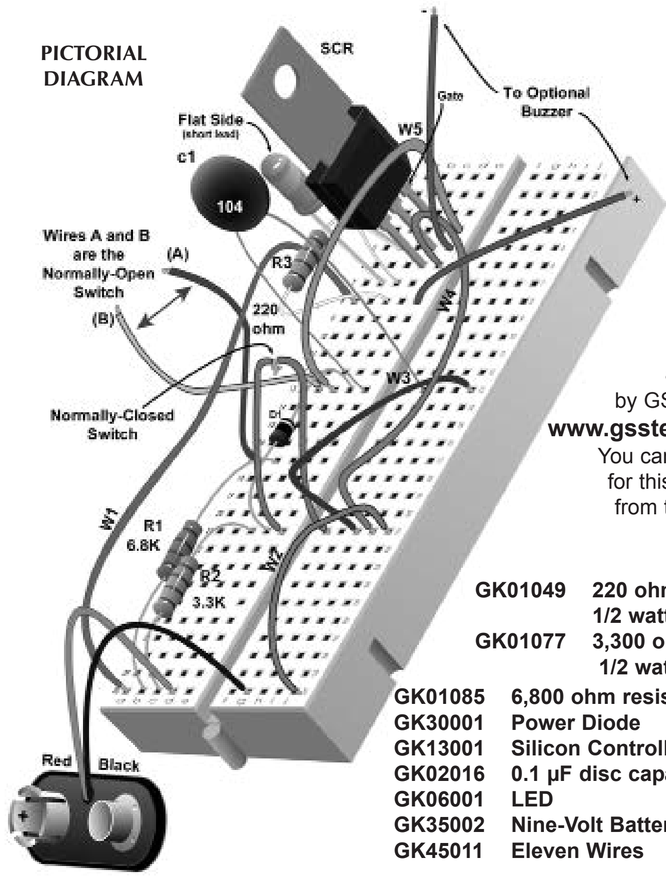
Connect solid wires as shown: W1 = 8a to 30a; W2 = 21j to 30j; W3 = 6e to 21i; W4 = 13j to 21h; W5 = 4e to 13c. Insert a single wire into each of the following holes: N/C switch = 21f and 21e; N/O switch = 17a and 13b; Buzzer = 5e and 8e. Be sure to twist the ends of wires 21f and 21e together; this forms a normally-closed switch.











These experiments are provided by GSSTechEd at **www.gssteched.com** You can order parts for this experiment from their website as follows:

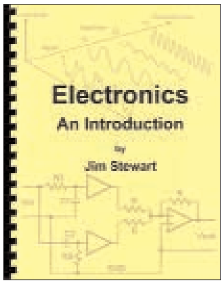
GK01049	220 ohm resistor 1/2 watt
GK01077	3,300 ohm resistor 1/2 watt
GK01085	6,800 ohm resistor 1/2 watt
GK30001	Power Diode
GK13001	Silicon Controlled Rectifier
GK02016	0.1 µF disc capacitor
GK06001	LED
GK35002	Nine-Volt Battery Snap
GK45011	Eleven Wires

For a complete product detail visit our webstore!!

The Nuts & Volts WEBSTORE

ELECTRONICS

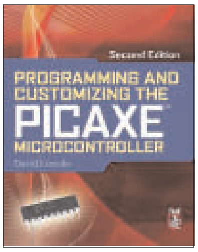
Electronics An Introduction
by Jim Stewart



This book is designed as an in-depth introduction to important concepts in electronics. While electronics can be highly mathematical, this text is not about calculations. It is about how electronic equipment is able to extract, process, and present information held in electrical signals. If you are in — or studying to be in — a profession that requires the use of electronic equipment, then this book will provide the insight necessary to use such equipment effectively. **$33.95***

Programming and Customizing the PICAXE Microcontroller 2/E
by David Lincoln

UNLEASH THE POWER OF THE PICAXE!



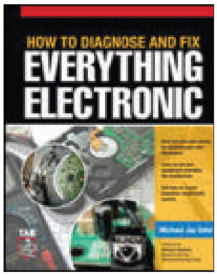
The PICAXE is a powerful and easy-to-use processor, capable of highly sophisticated projects, without the complexities and high costs of alternative chips. Beginners can produce tangible results within minutes, and experienced users can achieve truly professional results. This Second Edition has been fully updated for the latest hardware and software upgrades, and shows you step-by-step how to take full advantage of all the capabilities of the PICAXE and build your own control projects.

$49.95*

How to Diagnose and Fix Everything Electronic
by Michael Jay Geier

NEW!

Master the Art of Electronics Repair!



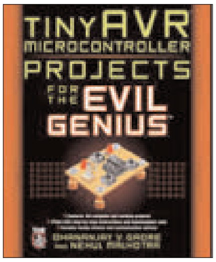
In this hands-on guide, a lifelong electronics repair guru shares his tested techniques and invaluable insights. *How to Diagnose and Fix Everything Electronic* shows you how to repair and extend the life of all kinds of solid-state devices, from modern digital gadgetry to cherished analog products of yesteryear.

About the Author

Michael Jay Geier began operating a neighborhood electronics repair service at age eight that was profiled in *The Miami News*.

$24.95

tinyAVR Microcontroller Projects for the Evil Genius
by Dhananjay Gadre and Nehul Malhotra

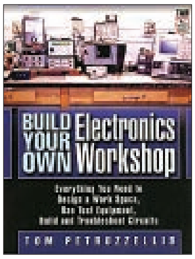


Using easy-to-find components and equipment, this hands-on guide helps you build a solid foundation in electronics and embedded programming while accomplishing useful — and slightly twisted — projects. Most of the projects have fascinating visual appeal in the form of large LED-based displays, and others feature a voice playback mechanism. Full source code and circuit files for each project are available for download.

$24.95

Build Your Own Electronics Workshop
by Thomas Petruzzellis

BUILD YOUR OWN DREAM ELECTRONICS LAB!



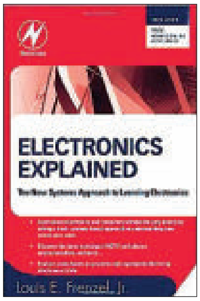
This value-packed resource provides everything needed to put together a fully functioning home electronics workshop! From finding space to stocking it with components to putting the shop into action -- building, testing, and troubleshooting systems. This great book has it all! And the best part is, it shows you how to build many pieces of equipment yourself and save money, big time!

Reg Price $29.95

Sale Price $24.95

Electronics Explained
by Louis Frenzel

The New Systems Approach to Learning Electronics



Don't spend time reading about theory, components, and old ham radios - that's history! Industry veteran, Louis Frenzel, gives you the real scoop on electronic product fundamentals as they are today. Rather than tearing electronics apart and looking at every little piece, the author takes a systems-level view. For example, you will not learn how to make a circuit but how a signal flows from one integrated circuit (IC) to the next, and so on to the ultimate goal.

$29.95

Making Things Move: DIY Mechanisms for Inventors, Hobbyists, and Artists
by Dustyn Roberts

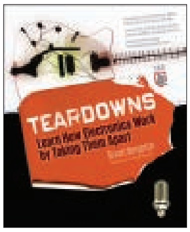
NEW!

In *Making Things Move: DIY Mechanisms for Inventors, Hobbyists, and Artists*, you'll learn how to successfully build moving mechanisms through non-technical explanations, examples, and do-it-yourself projects — from kinetic art installations to creative toys to energy-harvesting devices. Photographs, illustrations, screenshots, and images of 3D models are included for each project.

$29.95*

TEARDOWNS
by Bryan Bergeron

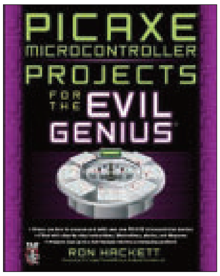
Learn How Electronics Work by Taking Them Apart



Amp up your knowledge of electronics by deconstructing common devices and analyzing the revealed components and circuitry. *Teardowns: Learn How Electronics Work by Taking Them Apart* contains 14 projects that expose the inner workings of household appliances, workbench measuring instruments, and musical equipment. Discover how resistors, capacitors, sensors, transducers, and transistors function in real circuitry.

Reg $24.95 **Sale Price $21.95**

PICAXE Microcontroller Projects for the Evil Genius
by Ron Hackett

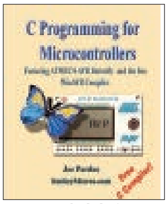


This wickedly inventive guide shows you how to program, build, and debug a variety of PICAXE microcontroller projects. *PICAXE Microcontroller Projects for the Evil Genius* gets you started with programming and I/O interfacing right away, and then shows you how to develop a master processor circuit.

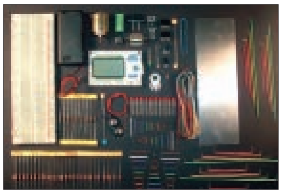
$24.95

Order online @ www.nutsvolts.com
Or CALL 1-800-783-4624 today!

BOOK & KIT COMBOS



From the Smiley Workshop C Programming for Microcontrollers
by Joe Pardue

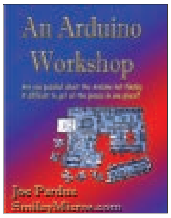


Book **$44.95**

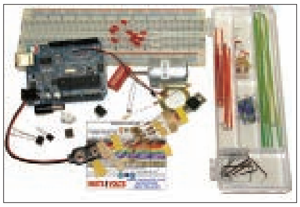
Kit **$66.95**

Do you want a low cost way to learn C programming for microcontrollers? This 300 page book and software CD show you how to use ATMEL's AVR Butterfly board and the FREE WinAVR C compiler to make a very inexpensive system for using C to develop microcontroller projects.

Combo Price $99.95 Plus S/H



From the Smiley Workshop An Arduino Workshop
by Joe Pardue

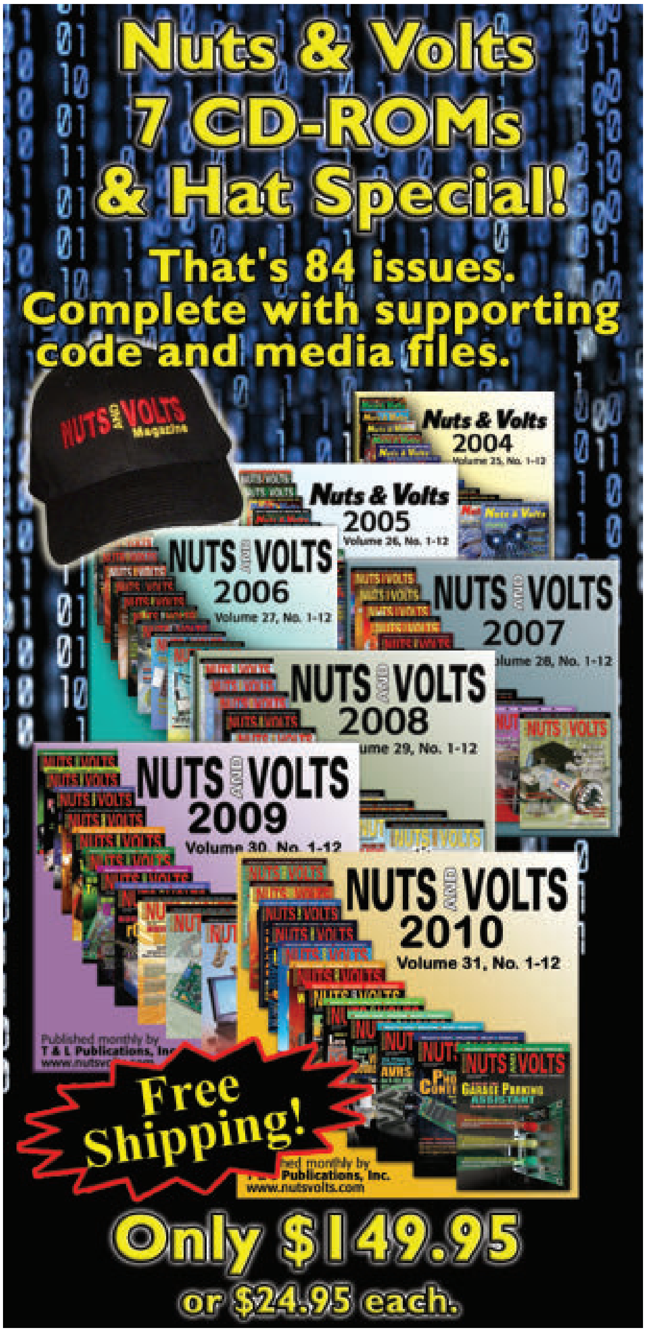


The book *An Arduino Workshop* and the associated hardware projects kit bring all the pieces of the puzzle together in one place. With this, you will learn to: blink eight LEDs (Cylon Eyes); read a pushbutton and 8-bit DIP switch; sense voltage, light, and temperature; make music on a piezo element; sense edges and gray levels; optically isolate voltages; fade an LED with PWM; control motor speed; and more!

An Arduino Workshop Combo

Reg Price $ 124.95 **Subscriber's Price $119.95 Plus S/H**

CD-ROM SPECIALS



This lab — from the good people at GSS Tech Ed — will show you 40 of the most simple and interesting experiments and lessons you have ever seen on a solderless circuit board. As you do each experiment, you learn how basic components work in a circuit. Along with the purchase of the lab, you will receive a special password to access the fantastic online interactive software to help you fully understand all the electronic principles. For a complete product description and sample software, please visit our webstore.

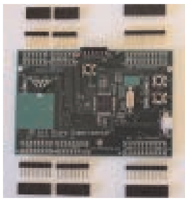
Reg Price $79.95 **Subscriber's Price $75.95**

This great little book is a concise all-purpose reference featuring hundreds of tables, maps, formulas, constants, and conversions. AND it still fits in your shirt pocket!

CALL 1-800-783-4624 today!
Or Order online @ www.nutsvolts.com

PROJECTS

32-Bit Micro Experimenter Board



The new 32-Bit Micro Experimenter is the fastest way to learn 32-bit microcontrollers.

The kit includes onboard 46 programmable I/O and USB, free software, carefully documented step-by-step experiments for USB, embedded web server, graphics & audio, wireless, RTOS, and file I/O. User pushbuttons, LEDs, and 32 kHz clock crystal. Can be used in solderless breadboard environment or stand-alone. Also supports Arduino compatible interface.

Subscriber's Price **$89.95**
Non-Subscriber's Price **$93.95**

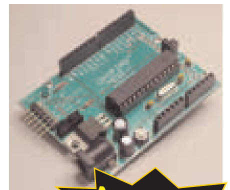
Piezoelectric Film Speaker Kit

As seen in the November 2010 issue, here is a great project to amaze your friends and to demonstrate a unique way of producing sound. Kit contains one piece of piezoelectric film, speaker film stand, PCB, components, audio input cable, and construction manual. All you'll need to add is a battery and a sound source.
For more info, please visit our website.

Subscriber's Price **$69.95**
Non-Subscriber's Price **$74.95**

CHIPINO Kit

The CHIPINO module is an electronic prototyping platform that is used in a series of articles starting with the March 2011 issue of *Nuts & Volts Magazine*.



Assembled units $29.95!

Developed by the CHIPAXE Team as a bridge between PICs and Arduinos. The module was designed specifically to match the board outline, mounting holes, connector spacing, and most of the microcontroller I/O functions found on the popular Arduino module.

Subscriber's Price **$18.95**
Non-Subscriber's Price **$19.95**

128x64 Graphic Display Kit

New application for the 16-Bit Micro Experimenter

LCD displays ... they have been around for quite some time, but what if you could have both characters, as well as graphic displays at the same time? With this kit, we will show you how easy and inexpensive this technology can be using the 16-Bit Micro Experimenter.

Subscriber's Price **$45.95**
Non-Subscriber's Price **$48.95**

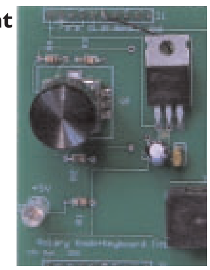
Mini-Bench Supply Complete Kit

A small power supply with +5V, +12V, and -12V outputs is a handy thing to have around when you're breadboarding circuits with both op-amps and digital ICs.
Kit includes: Enclosure box, accessories, DC-to-DC converter kit, switching regulator kit, and article reprint.
For more information, please see the "feature article section" on the of the *Nuts & Volts* website.

Subscriber's Price **$76.95**
Non-Subscriber's Price **$83.95**

The Mini Kit

The best experiment yet for the 16-Bit Experimenter Board.



Adding this Mini Kit to your Experimenter Board will enhance the Experimenter. The Mini Kit is a user interface with a rotary encoder using the PIC24F timer peripheral set and its interrupt capability. For more information, see the December 2010 issue. Assembled units also available.

Subscriber's Price **$36.95**
Non-Subscriber's Price **$39.95**

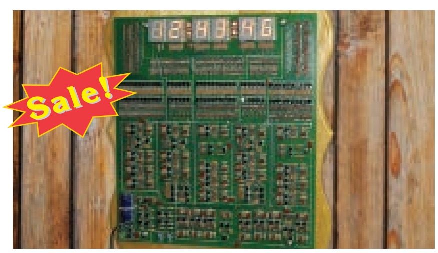
16-Bit Experimenter Handbook

From the series of articles by Tom Kibalo, The Complete 16-Bit Experimenter Handbook on CD-ROM!

This CD-ROM handbook contains: 200 pages of detailed instructions and 41 experiments with 'C' software examples. Also includes the experiments for the dsPIC33.
For a complete list of kits and combos, please visit our webstore.

Subscriber's Price **$64.95**
Non-Subscriber's Price **$69.95**

Transistor Clock Kit



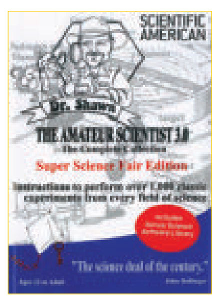
If you like electronic puzzles, then this kit is for you! There are no integrated circuits; all functionality is achieved using discrete transistor-diode logic. The PCB is 10"x11" and harbors more than 1,250 components! For more info, see the November 2009 issue.

Reg $225.95
Sale Price $199.95

PCBs can be bought separately.

The Amateur Scientist 4.0 The Complete Collection

by Bright Science, LLC



There are 1,000 projects on this **CD**, not to mention the additional technical info and bonus features. It doesn't matter if you're a complete novice looking to do their first science fair project or a super tech-head gadget freak; there are enough projects on the single CD-ROM to keep you and 50 of your friends busy for a lifetime!

Reg $26.95 Sale Price $23.95

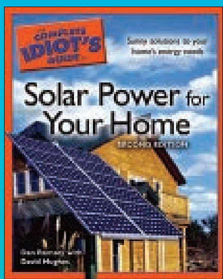
WE ACCEPT VISA, MC, AMEX, and DISCOVER. Prices do not include shipping and may be subject to change.

Attention **Subscribers ask about your discount on prices marked with an ***

The Nuts & Volts **WEBSTORE**

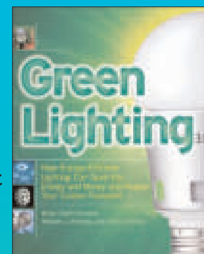
ALTERNATIVE ENERGY SECTION

The Complete Idiot's Guide to Solar Power for Your Home
by Dan Ramsey / David Hughes



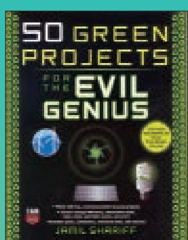
The perfect source for solar power — fully illustrated. This book helps readers understand the basics of solar power and other renewable energy sources, explore whether solar power makes sense for them, what their options are, and what's involved with installing various on- and off-grid systems.
$19.95

Green Lighting
by Brian Clark Howard, Seth Leitman, William Brinsky
Flip the switch to energy-efficient lighting!



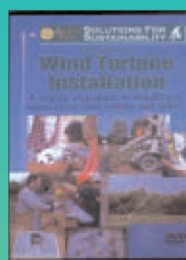
This do-it-yourself guide makes it easy to upgrade residential and commercial lighting to reduce costs and environmental impact while maintaining or even improving the quality of the lighting. Filled with step-by-step instructions and methods for calculating return on investment, plus recommended sources for energy-efficient products.
$24.95

50 Green Projects for the Evil Genius
by Jamil Shariff



Using easy-to-find parts and tools, this do-it-yourself guide offers a wide variety of environmentally focused projects you can accomplish on your own. Topics covered include transportation, alternative fuels, solar, wind, and hydro power, home insulation, construction, and more. The projects in this unique guide range from easy to more complex and are designed to optimize your time and simplify your life!
$24.95

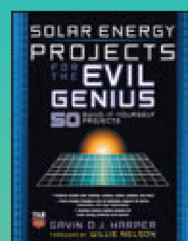
Wind Turbine Installation DVD



Manuals can sometimes be confusing, especially for people who learn by seeing how things work. So, this DVD takes the viewer step-by-step through the entire installation process, from choosing a site, to running wire, assembling the tower, and finally using a winch for the final lift. This is a must-watch for anyone planning on installing a wind turbine who wants to learn the process and the proper techniques for a safe and successful installation.

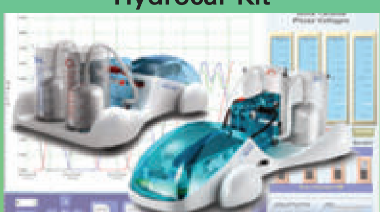
$19.95*

Solar Energy Projects for the Evil Genius
by Gavin D J Harper



Let the sun shine on your evil side — and have a wicked amount of fun on your way to becoming a solar energy master! In *Solar Energy Projects for the Evil Genius*, high-tech guru Gavin Harper gives you everything you need to build more than 30 thrilling solar energy projects. You'll find complete, easy-to-follow plans, with clear diagrams and schematics, so you know exactly what's involved before you begin. **$24.95**

Hydrocar Kit



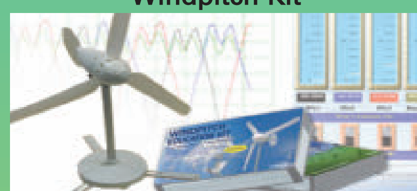
The Hydrocar is used in a couple of great projects from the series of articles by John Gavlik, "Experimenting with Alternative Energy." In Parts 10 and 11, he teaches you the operation of the Polymer Electrolyte Membrane "reversible" fuel cell.
For kit details and a demo video, please visit our webstore.

Subscriber's Price **$79.95**
Non-Subscriber's Price **$84.95**

Solar Hydrogen Education Kit

The Solar Hydrogen Education Kit includes a solar cell, a PEM reversible fuel cell, oxygen and hydrogen gas containers, and more! The set only needs pure water to create hydrogen and produce electricity. Perfect for science labs, classroom use, or demonstration purposes.
Subscriber's Price **$56.95**
Non-Subscriber's Price **$59.95**

Windpitch Kit



The WindPitch Wind Turbine Kit is a miniature real-working wind turbine and is one of the great projects from the series of articles by John Gavlik, "Experimenting with Alternative Energy." In Parts 8 and 9, he teaches you how to produce the most power by evaluating the pitch (setting angle) of the profiled blades. For kit details, please visit our webstore.
Subscriber's Price **$94.95**
Non-Subscriber's Price **$99.95**

continued from page 9

After I run through a couple tanks of gas, I plan to add a variable brightness control to it. Thanks for the project.

Reuben Garcia
via email

OFF THE WALL WART

I was very interested in the article "Build a Wall Wart Power Monitor" by David Goodsell, in the February issue of *Nuts & Volts*. I have used a setup like his **Figure 1**, and I agree I need something better for measuring current. I'm planning to build a much simpler circuit which will produce the same results at a much lower cost. I have thought of two ways of doing this. The simplest way is to make an adapter for a digital multimeter. The adapter would contain the input and output connectors, the current sense resistor (R14, 0.1 ohm, three watts), a switch to select current or voltage measurement, and a pair of tip jacks to accept the tips of the meter probes. An auto-ranging DMM would be easiest to use.

If I want to use an on-board digital panel meter, I can simplify the circuit, reducing the parts count by about 50% and the cost by at least 60%, but with slightly shorter battery life. I would replace the low duty flasher circuit with a low current (2 mA) LED. I have used these for 20 years in

CLASSIFIEDS

battery powered devices. Most parts suppliers have them, but you may have to look through the LED listings to find them. The battery monitor can be replaced with a pair of tip jacks connected to the battery for measuring with a separate DMM, or modifying the circuit to allow the on-board DPM to also measure the battery voltage.

The largest reduction in cost is the DPM. The Martel DPM specified is over $28. There are a number of made-in-China DPMs with nearly identical specs, available in the $10 range (one is $7.27). A quick check found eight parts suppliers (including three who are regular advertisers in *Nuts & Volts*) who sell these meters. Circuit Specialists alone has 14 models of LCD DPMs — about eight of which would be direct replacements for the specified Martel meter. Other suppliers include Jameco Electronics and All Electronics. I have been using these meters for nearly 20 years, and they work fine. They usually don't have a brand name. Some of the boxes have a stylized "C + C" emblem, and a few meter circuit boards and instruction sheets have the name "Colluck." Besides price, an advantage of these meters is that they don't have the flaky mounting described by Mr. Goodsell. Most of them mount with two small captive screws; a few are snap-in.

In late 2003, an improved unit was introduced which — without raising the price — contains internal voltage divider resistors (ranges of 0.2, 2, 20, 200, and 500 VDC) and can have the negative power terminal connected to the common input terminal. These can be easily connected so that the meter can measure its own battery voltage.

They could be connected to use the wall wart being measured to power the DPM, but they wouldn't work for wall warts below about seven or eight volts, unless you used a "boost" switching regulator. They also wouldn't work when the center terminal is negative.

These meters don't seem to be very well known. *Nuts & Volts* published "Extending the Range of the Digital Voltmeter Module" by David Ponting in March '03 and an article by Fred Blechman about 10 years ago. I wrote a seven page article, "Using Digital Panel Meters," that was published in *Popular Electronics* in October '96. I don't remember any others.

Bill Stiles
via email

LETTING OFF STEAM

Was it really necessary for *NV* to waste more than two full content pages on four letters from self-proclaimed "experts" to inform us that steam is hot? One letter, okay but four? While we are at it, we ought to let everyone know that solder is HOT, too. Hotter than steam, even. Electricity is not too safe, either. Kills people all the time. Three page safety article to follow ...

Mark Lewus
Denville, NJ

>>> QUESTIONS

Flicker And Fade

I had a dilemma last Halloween that I'm hoping someone could help me with. I wanted to make a flickering light display using an incandescent light bulb (not an LED, in order to keep the look authentic). I had heard that hooking a fluorescent starter in series with the bulb would produce the effect. However, it just made the light blink like an oversized Christmas light. I want a bulb that flickers and fades — something that gives the illusion that the power is fluctuating and could possibly fail at any moment. Any suggestions?

#6111 **Brian Manriquez**
Huntington, WV

Precision 60 Hz Reference

I'm looking for a simple, highly stable 60 Hz reference AC signal. AC power lines are accurate over long timeframes, but can fluctuate short term. I've seen suggestions of taking a color burst crystal and dividing down, but filtering is necessary to reach an AC waveform. Hope someone has an elegant solution.

#6112 **Art Wong**
Brampton, Ont

Voice Mail Alert

I need a circuit to connect to my telephone wiring so the ring signal will cause an LED to light up and stay lit until it is manually turned off. The system is VOiP via modem and ATA.

#6113 **Mike Knoll**
Seattle, WA

LED Flasher Circuit

I want to make a high power LED flasher circuit with a PIC by using 15 three watt power LEDs and two pushbutton switches.

When the first button is pressed, it will blink four times per second and will wait one second.

When the second button is pressed, it will blink two times per second and will wait one second.

The circuit will be powered by a 12 volt/72 amp auto battery and will be used in an ambulance.

#6114 **Selahattin Sadoglu**
via email

Wood Shop Dust Vacuum Circuit

I would like to know how to build a sensor to turn my dust vacuum on in my wood shop when I turn my saw or other machines on.

#6115 **John Pillen**
via email

Points Ignition To Solid-State

Can someone help with a crossover design or existing schematic to turn my 1989 points ignition to a solid-state design? Four cylinder — OMC or Ford 2.3 140.

#6116 **Rok**
Cleveland, OH

AC Resistance Needed

How can I find the AC resistance of the emitter diode of a power transistor?

#6117 **Carl Blaettler**
via email

>>> ANSWERS

[#4113 - April 2011]
Sequential Start Bell Controller

In German church towers, bells are pealed with reversing motors or magnetic-repulsion devices. Multiple-bell peals generally begin with the smallest bell, with bells of increasing size added every 10 seconds or so, until all are pealing. At the end of the peal, they are stopped in the same order. I'm looking for a circuit with several relay outputs in which each relay switches on in sequence every 10 seconds or so when current is applied, and switches off in the same order when current is cut. Basically, it is a power sequencer circuit that is expandable to more outputs if bells are added in the future.

Figure 1 is one of several possible circuits. The key component is the 74LS164 eight-bit serial-to-parallel shift register. Data at the 'data in' line will be transferred to the outputs Qa through Qh sequentially on the rising edge of the clock pulse.

A constant high at the data in-line (as produced by the 'Q' output of section 'B' of the 74LS74 — a dual D flip-flop — when S2 is pressed) will cause each SR output to go high and stay high. Any output can be used as the last output. Qh is just an example. The LS164 can be expanded very easily by connecting Qh to the data in line of the next SR and tying the clocks together. The outputs need to go to the base of a transistor or the LED of an optocoupler of your interface circuit as these parts don't have the "umph" to power a bell (or bells). R4 and R5 maintain the inputs of the Schmitt-triggered inverters at a constant low — just below their trigger points, thus, their outputs remain high most of the time.

C1 differentiates the last output pulse of the chain and because of the long tail acquired in the process, the inverters create a nice sharp and short negative going pulse, regardless of the length of the SR output pulse. The 555 is configured as an astable MV with a period of about 10 seconds. The

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process is started by pressing S1, then S2, then S3. After all outputs are turned on, the last output will inhibit the clock and make data in a constant low. After you have had enough of the bells (or whatever), press S3 a second time to start turning off all the outputs sequentially. After all outputs are off, the clock will still be running, but only zeros are going out. Press S1 if you want. S1 can also be used as an abort function that will stop the clock and clear all outputs to zero immediately. A µC could be used for S2 and S3.

Phillip Potter
via email

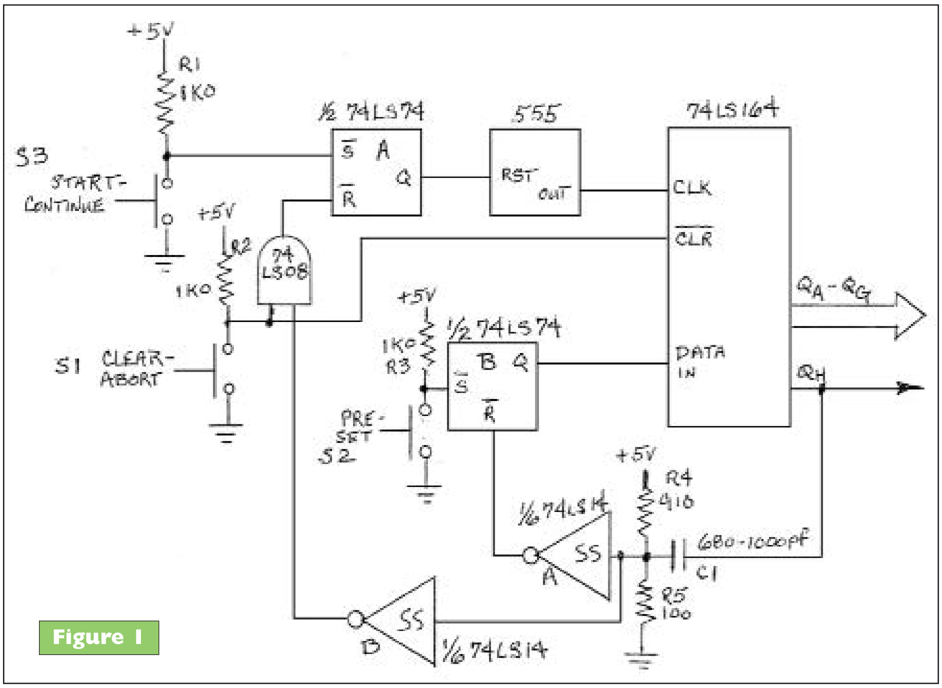
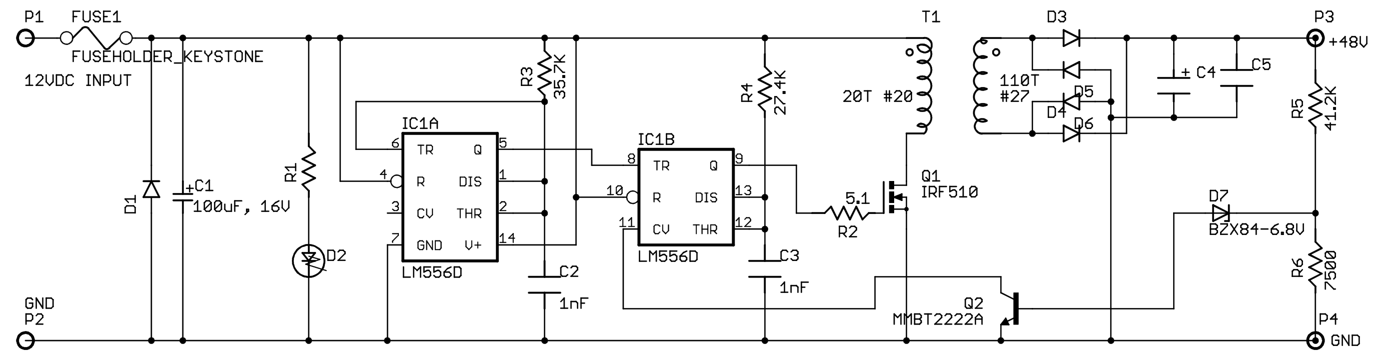


Figure 1

[#5111 - May 2011]
Toying With Tektronix Scope

I have some internal parts to an old Tektronix oscilloscope that I would like to "light up" but have no



PARTS LIST

PART	DESCRIPTION	PKG	MOUSER PART NUMBER
FUSE	5A, 5 x 20MM		504-GDB-5A
D1, D2, D3, D4, D5, D6	2A, 100V	SMB	621-B2100-F
D2	RED LED	T1 3/4	
D7	ZENER, 6.8V, 20mA	SOT23	771-BZX84J-B6V8,115
C1	100 uF, 16V, TANTALUM	7343	74-293D107X9016D2TE3
C2, C3	1000pF, 50V, 5%, COG	0805	140-CC501N102J-RC
C4	47uF, 100V	10MM	140-VZH470M2ATR1010
C5	.1uF, 100V, CERAMIC	1206	581-12061C104K4
R1	2K, 1/8W, 1%	1206	290-2.0K-RC
R2	5.1 OHM, 5%, 1/8W	1206	263-5.1-RC
R3	35.7K, 1%, 1/8W	1206	290-35.7K-RC
R4	27.4K, 1%, 1/8W	1206	290-27.4K-RC
R5	41.2K, 1%, 1/8W	1206	290-41.2K-RC
R6	7.5K, 1%, 1/8W	1206	290-7.5K-RC
IC1	556 DUAL TIMER	SO14	595-NE556DRE4
Q1	NMOS, 100V, 5A	TO220	844-IRF510PBF
Q2	NPN, 30V, 500MA	SOT23	863-MMBT2222ALT3G
T1	R. S. RF CHOKE	273-104	RADIO SHACK

Figure 2

technical manual. I would love to see a trace on the scope tube. The tube is direct-connected on the Y axis through a delay line such as was used on old radiation detectors at Argonne and elsewhere. I have no idea about the pin-out but some resistors are still attached as a starter. I don't hope to restore it (as I just did on an old Sylvania), but would like to have one hell of a toy.

You don't say what model Tektronix you have, but I have a book of schematics that covers RM15 up to 575 transistor curve tracers and am willing to copy and send schematics for your scope. No charge to Mr. Gibson but $10 to others. Model 541 schematics are 19 pages. You can contact me by email at **russlk@yahoo.com**. Put Tektronix schematics in the subject line so I can easily find it in the spam folder. Ironically, the transistor curve tracer is a tube circuit.

Russ Kincaid
Milford, NH

[#5112 - May 2011]
1.5 VDC Motor On
1.5 VDC Battery

If I ran a 1.5 VDC motor continuously off of a 1.5 VDC battery, how do I figure the approx. life expectancy of the battery (in hrs)?

What you need to know is how much load current the 1.5 VDC motor draws when it is under power. From there, you can determine the life expectancy of the battery. To determine the battery life/hours, divide the battery capacity by the load current of the motor to get the hours of life the battery will have. The ollowing site has a table for alkaline batteries, their mAh capacities, and their typical current drain in mA. From the information in the table there, you can determine how long the battery will last when connected to the motor. **www.batterysavers.com/Compare-Batteries.html**

Ralph J. Kurtz
Old Forge, PA

[#5115 - May 2011]
DC-DC Voltage Booster

I need to get 48V DC at around 350 mA from a battery pack. A 40 cell battery pack is a bit much, so I was thinking of boosting a 12V or 18V pack. Would something simple like a 555 driving a power FET into a step-up transformer with the usual rectification/smoothing circuit on the output work? The load should be fairly constant and regulation not too stringent (.5V either way).

#1 Yes, the 555 idea will work but a 556 (dual timer) can provide regulation, see **Figure 2**. I have used this circuit in flyback mode but the power here (17 watts) is too high, so this is a forward converter. The first timer is astable, running at 40 kHz; the second timer is a one shot whose time is less than the astable, but it gets triggered at the 40 kHz rate. The feedback shortens the one shot pulse width to regulate the output voltage. The battery current will be two amps at 12 volts with a fresh battery and will increase as the battery voltage falls.

Transformer cores for 40 kHz are hard to find but RadioShack #273-104 will work. I would discard the plastic case and hold the core, together with a zip tie after winding. It is not desirable to store energy in the core so the primary impedance should be as high as practical. Using equations from the Magnetics, Inc., ferrite cores manual, I get 20 turns #20 wire for the primary and 110 turns #27 wire for the secondary. You should make a bobbin or tape the core so the sharp edges don't cut the wire insulation.

Russ Kincaid
Milford, NH

#2 I would suggest the simplest solution is to purchase a converter made to convert 12 VDC to 48 VDC on eBay. There is one available that will supply up to 850 ma for about $55 counting shipping. It looks to be the size of a laptop power/supply/charger.

Jeff Ohlson
via email

#3 I think you are unlikely to experience an improvement in tinnitus symptoms via this technique. An out-of-phase cancellation will work only if there is an actual incoming signal to cancel, but by definition, tinnitus is a spurious electrical signal transmitted from your ear to your brain, caused by damaged or bent hairs in the inner ear corresponding to a particular frequency. There is no actual "input" signal to cancel.

The online article from the Mayo clinic discussing treatments for tinnitus (**www.mayoclinic.com/health/tinnitus/DS00365/DSECTION=treatments-and-drugs**) mentions white noise machines, hearing aids, masking devices (basically an in-ear white noise machine), and tinnitus retraining devices — all of which focus on masking your perception of the frequencies via psychological perception masking techniques rather than a physical elimination of the problem. The problem lies in a faulty sensor (the hairs in your inner ear) rather than an actual sensor "input" that can be modified via phase cancellation. I would, of course, strongly suggest consulting your doctor and an auditory specialist, if you haven't already.

Andy
Redmond, WA

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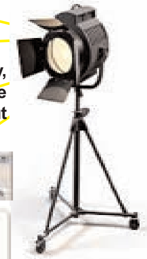

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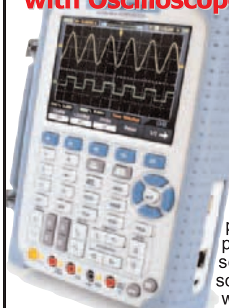

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